OPERATING AND SERVICE MANUAL

(HP PART NO. 03406-90001)

MODEL 3406A
BROADBAND
SAMPLING VOLTMETER

FOR REFERENCE PURPOSES ONLY

SERIALS PREFIXED: 625- *

*Section VII Page 7-2 and 7-3, Manual Backdating Changes, adapts manual to serials below:
625-00476 and 606-.

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MANUAL CHANGES

MODEL 3406A

BROADBAND SAMPLING VOLTMETER

Manual Serial Prefixed: 625-
-hp- Part No. 03406-90001

► New or revised item

Instrument Serial Number	Make Manual Changes
ALL	ERRATA
625-00551 to -00750	Change #1
625-00751 to -01000	Change #1 and #2
625-01001 to -01170	Change #1, #2, & #3

Instrument Serial Number	Make Manual Changes
830-01171 to -01310	Change #1, #2, and #3
841-01311 & above	Change #1, 2, 3 and 4

ERRATA: Page 1-0, Table 1-1, Specifications:

1. Change Full-Scale Accuracy as follows:

10kHz	20kHz	25kHz	100kHz	100MHz	700MHz	1GHz	1.2GHz
±13%	±8%	±5%	±3%	~~±6%~~ 5%	±8%	±13%	

see M.T.O. clip

► 2. Under Sample Hold Output add the following:

Output Level: 316 mV full scale on all ranges.

Change the Noise specification:

Noise: < 56 mV on 1 mV range (175μV referred to the input)
< 1/10 full scale 3 mV range
< 1/20 full scale all other ranges

OPERATING INSTRUCTIONS, Section III

1. Add the following:
1 MV RANGE MEASUREMENTS

If the probe body temperature exceeds 30°C when using the .001 V range perform the following zeroing procedures to minimize the effects of noise and assure accuracy.

1. For readings below 1/3 scale on the 1 mV range zero the 3406A on the 1 mV range with the probe inserted into a terminated 50Ω tee at the temperature of measurement.
2. For readings above 1/3 scale on the 1 mV range zero the 3406A on the 1 volt range with the probe inserted into a terminated 50Ω tee at the temperature of measurement.

NOTE

If a 50Ω tee is not available insert the probe - at temperature of measurement - into the 1 V receptacle with the CAL pushbutton released and adjust the ZERO as rapidly as possible.

ERRATA (Cont'd):

Page 3-3, Paragraph 3-15:

1. Change Insertion Power Loss of 50 Ohm Tee to < 1 dB up to 1 GHz.

Page 5-6:

1. After paragraph 5-15 add the following paragraph.

5-15a. SAMPLE HOLD OUTPUT NOISE CHECK

a. Connect an AC Voltmeter (-hp- Model 400E) to SAMPLE HOLD OUTPUT jack on the 3406A rear panel.

b. Position AC Voltmeter range selector to 100 mV range.

c. With the CAL pushbutton on 3406A released insert probe into 1 VOLT receptacle.

d. Depress 3406A .001 V range pushbutton and observe meter indication of < 55 mV on the voltmeter connected to the SAMPLE HOLD OUTPUT. This verifies the Sample Hold Output noise of < 175 μV referred to the input.

NOTE

The Sample Hold Output voltage is 316 mV full scale for all ranges. On the 1 mV range 50 dB of gain is provided for Sample Hold Output. Therefore < 175 μV of noise x 50 dB of gain equal < 56 mV. See Section III for additional information concerning Sample Hold Output.

Page 5-10:

1. Change the last four steps (e, f, g and h) of Paragraph 5-29 to h, i, j and k, respectively.
2. Change the last step in Paragraph 5-29 to read: If 3406A reading is not within 1% of reading noted in step g, repeat the entire procedure.

Section VI:

1. Replaceable Parts Table should be Table 6-1.
2. Change -hp- Part No. for A1 to: "See Note".
3. Change -hp- Part No. for A2Q7 and A3Q3 to 1855-0073.
4. Page 6-9, change Part No. of A3C2 to 0160-0152, and change Part No. of A3CR15-CR18 to 1901-0158.
5. Page 6-12, change -hp- Part No. for J10 to 1251-0198.

Page 7-11, Sample Hold Circuit:

1. Add asterisk to A2R28. The value of A2R28 is factory selected to match the gain of A2Q7 to the Sampling Probe Assembly.

ERRATA (Cont'd)

Procedure for selecting value of A2R28: (1.5K to 3.3K).

a. ZERO the Model 3406A according to Paragraph 3-8.
b. Insert bare probe into 1 VOLT receptacle; depress 1 volt RANGE and CAL pushbuttons.
c. Adjust front panel CALIBRATE control from full CW to full CCW and note meter indication at both ends. Range of CALIBRATE control should be from .8 to 1.2 V.
d. Decrease value of A2R28 to obtain .8 reading; increase value of A2R28 to obtain 1.2 reading.

2. Change dc voltage at collector of A2Q3 to +.54 Vdc.

Page 7-13, Metering Circuits:

1. The dc voltage level (-10 V DC F.S.) across the meter is measured at the collector of A3Q5.

Page 7-14, Figure 7-7:

1. Change sweep time for waveforms (7) and (8) to 20 ms.
2. Change Vert sensitivity for waveform (9) to 5 V/cm.

Page 7-15, Pulse Generator Circuits and Replacement Parts Section VI:

Change value of A3C12 to 47 μF, -hp- Part No. 0180-0097.

CAHNGE #1

NOTE

Instruments with the following serial numbers also have Change #1 incorporated:

625-00463	625-00505	625-00523	625-00546
625-00483	625-00507	625-00530	
625-00492	625-00508	625-00532	
625-00498	625-00518	625-00539	
625-00502	625-00521	625-00540	

Page 7-11, Attenuator and Replaceable Parts Section VI:

1. Change value of S1R13 to 210 ohms. -hp- Part No. 0698-4574.
2. Add a 5K ohm variable resistor, S1R15, -hp- Part No. 2100-1775 in parallel with S1R13.

Page 5-11, Non-Linear Meter Amplifier Adjustment:

1. After Paragraph 5-37 step P add the adjustment of S1R15:

   Depress 3406A 3 volt RANGE pushbutton and increase oscillator attenuator by 40 dB; adjust 3 V FS (variable resistor S1R15 on range switch) for 3406A meter reading of 1 on 0 to 1 scale.

CHANGE #1 (Cont'd)

NOTE

Interaction exists between the 3 V FS adjustment and the 1 volt range. Check full scale deflection on 1 volt range and optimize adjustment of 3 V FS if necessary.

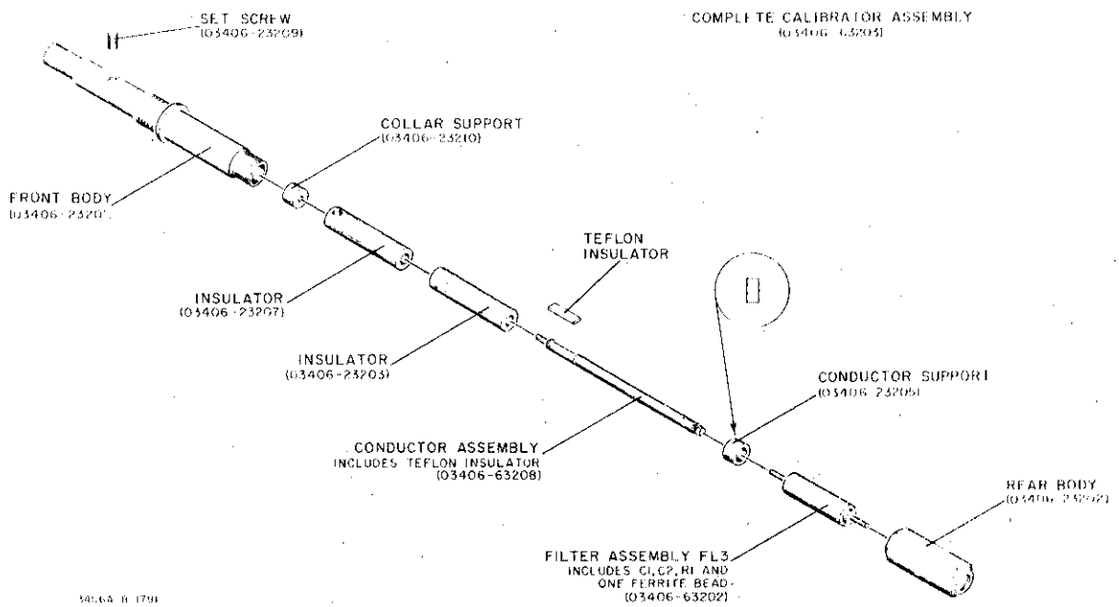
CHANGE #2: Page 7-11, Sampling Probe Assembly Schematic:

1. Change value of capacitor C1 to 470 pF.
2. Change value of capacitors C5 and C6 to 0.01 μF.

CHANGE #3: (1 VOLT CALIBRATOR CHANGE)

Page 7-16, Figure 7-9, Calibrator:

1. Change the exploded view of calibrator assembly as follows:



Page 6-13, Replaceable Parts:

1. Under Miscellaneous change Assembly; calibrator - from 03406-63201 to 03406-63203, and under description make reference to Figure 7-9.

Page 5-12, Adjustment and Calibration Procedures:

1. Add the following procedure between Paragraphs 5-39 and 5-40.

CHANGE #3 (Cont'd)

CALIBRATOR ASSEMBLY ADJUSTMENT.

On Instrument with serial numbers 625-01001 and above an Allen screw adjustment on the calibrator assembly is used to match the impedance of the 1 VOLT receptacle to a 11063A 50Ω tee. This Allen screw adjustment is not part of normal adjustment and calibration procedure. It is factory set and does not require readjusting unless complete calibrator assembly is installed or unless parts within the calibrator have been replaced.

With a 1 MHz signal at 1 V operating into a loaded 11063A 50 ohm tee, proceed as follows:

NOTE

The Adjustment and Calibration of 3406A must be complete up through Paragraph 5-37 as outlined in Operating and Service Manual.

a. Insert probe with 11027A Isolator tip into tee, and note indication on 3406A meter.

b. Place probe with Isolator tip into 1 VOLT receptacle and adjust (21) CALIBRATOR OUTPUT for same meter indication noted in Step a.

c. Remove Isolator tip and insert bare probe into 50 ohm tee, and verify 3406A meter indication of 1 V.

d. Insert bare probe into 1 volt receptacle and adjust Allen screw for 1 V indication on 3406A meter.

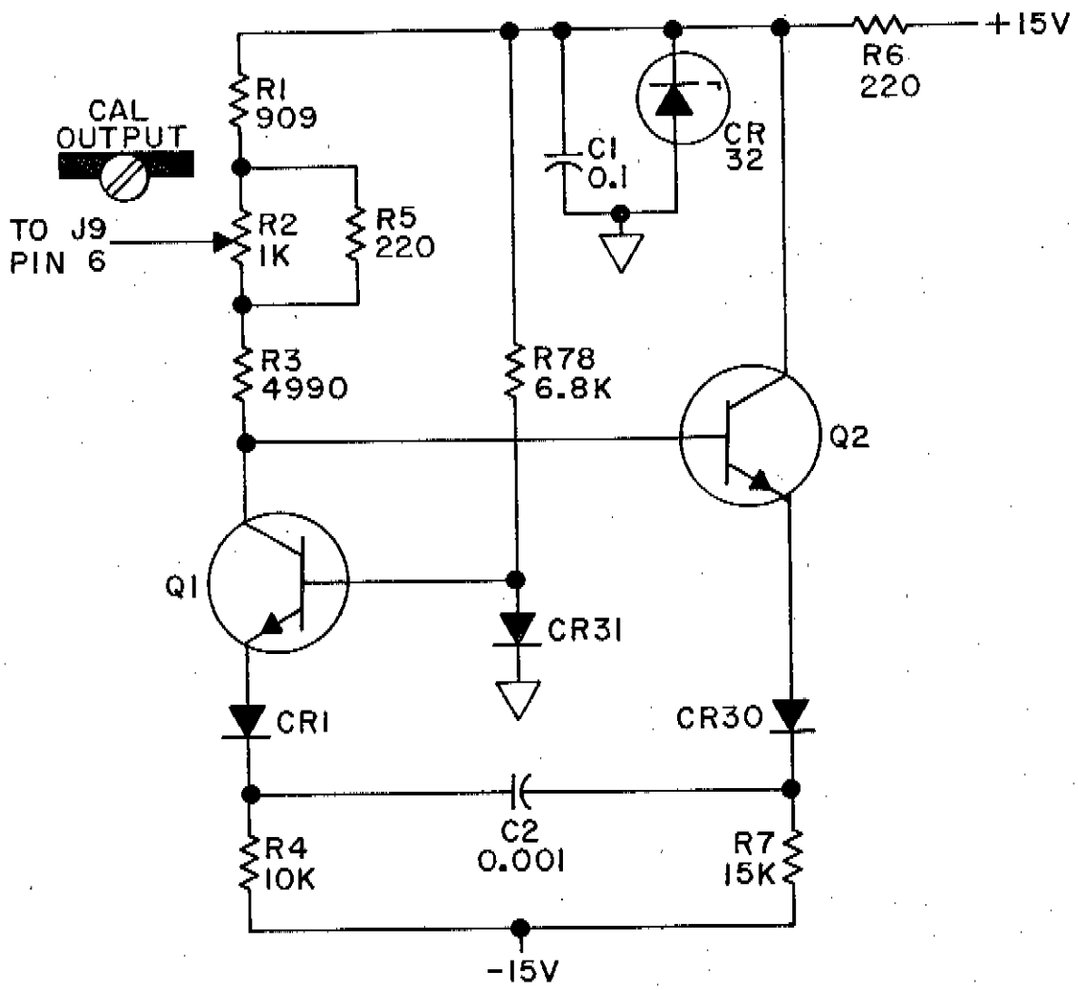
► CHANGE #4 The calibrator was changed to improve temperature characteristics:

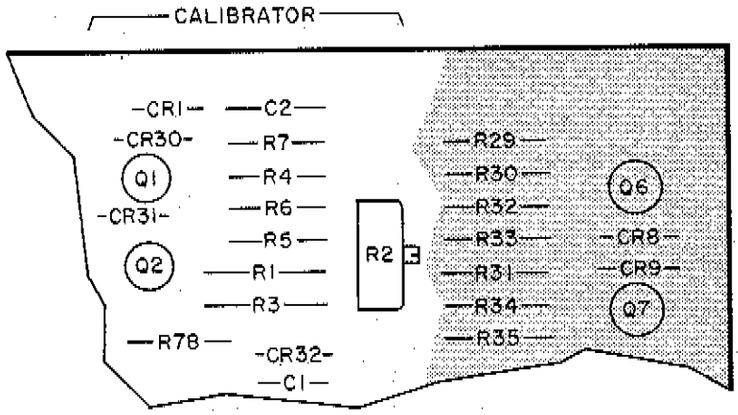
Page 7-16, change calibrator schematic as shown.

Page 6-9 and 6-10 Replaceable Parts A3:

1. Change A3C1 to 0.1 μF (-hp- Part No. 0150-0084).
2. Add A3CR30 and CR31 diode, (-hp- Part No. 1901-0040).
3. Add A3CR32 diode, breakdown 13V (-hp- Part No. 1902-3190).
4. Change A3R3 to 4990Ω ±1% 1/4 W (-hp-Part No. 0698-3208).
5. Change A3R6 to 220Ω ±10% 1/2W (-hp-Part No. 0687-2211).

CHANGE #4 (cont'd)





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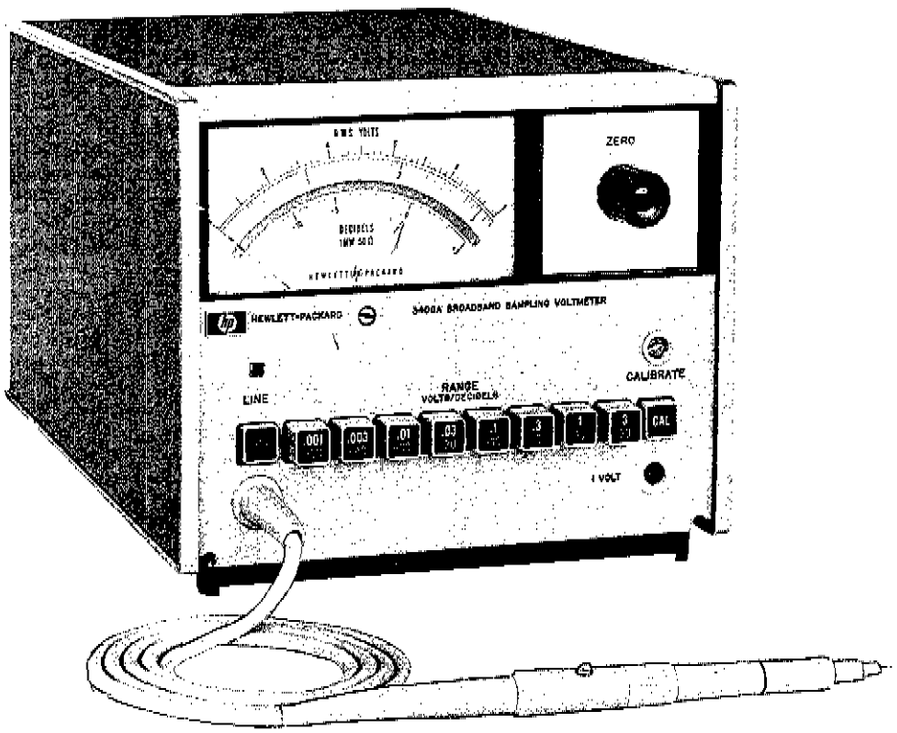


Figure 1-1. Model 3406A Broadband Sampling Voltmeter

Table 1-1. Specifications

Voltage Range: 1 mV to 3 volts full scale in eight ranges; decibels from -50 to +20 dBm (0 dBm= 1 mW into 50 ohms); absolute average-reading instrument calibrated to rms value of sine wave.

Frequency Range: 10 kHz to 1 GHz; useful sensitivity from 1 kHz to beyond 2 GHz.

Full-Scale Accuracy with Calibrator:
±3%, 100 kHz - 100 MHz
±5%, 25 kHz - 700 MHz
±8%, 10 kHz - 1 GHz
±1 dB, 5 kHz - 1.2 GHz

Input Impedance: 100,000 ohms at 100 kHz. Capacity >2.1 pF. Input capacity and resistance will depend upon accessory tip used. (<10 pF with 11072A isolator tip supplied).

SAMPLE HOLD OUTPUT:
Provides ac signal whose unclamped portion has statistics that are narrowly distributed about the statistics of the input, inverted in sign, (operating into >200 kΩ load with <1000 pF).

Noise: <225 μV rms.

Accuracy with Calibrator:
0.01 V Range and Above: Same as Full Scale Accuracy of Instrument.
0.001 V to 0.003 V Range: Value of input signal can be computed by taking into account the residual noise of the instrument.

Jitter: Meter indicates within ±2% peak of reading, 95% of the time (with an -hp- Model 3400A).

RMS Crest Factor: 0.001 V to 0.3 V: 20 dB, 1 V: 13 dB, 3 V: 3 dB

METER:
Meter Scales: Linear voltage, 0 to 1 and 0 to 3; decibel, -12 to +3. Individually calibrated taut band meter.

Response Time: Indicates within specified accuracy in < 3 sec.

Jitter: ±1% peak (of reading).

GENERAL:
DC Recorder Output: Adjustable from zero to 1.2 mA into 1000 ohms at full scale proportional to meter deflection.

Overload Recovery Time: Meter indicates within specified accuracy in < 5 sec. (30 V pk-pk max)

Maximum Input: ±100 Vdc, 30 V pk-pk.

RFI: Conducted and radiated leakage limits are below those specified in MIL-6181D and MIL-1-16910C except for pulses emitted from probe. Spectral intensity of these pulses are approximately 50 nV/$\sqrt{\text{Hz}}$; spectrum extends to approx. 2 GHz.

Temperature Range:
Instrument: 0 to +55° C, Probe: +10°C to 40°C.

Power: 115 or 230 volts ±10%, 50 Hz to 1000 Hz, nominally < 20 watts.

Dimensions: Standard 1/2 module 6-1/2" high, 8-7/8" wide, 11-1/2" deep (165x225x292 mm).

Weight:
Net 12 lbs. (5, 4 kg)

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 3406A Broadband Sampling Voltmeter. A general description and various applications of the instrument are described in the following paragraphs. The published specifications are given in Table 1-1. The accessories supplied with the instrument and accessories available are identified in Table 1-2 and 1-3. Instrument/Manual Identification is also included in this section.

1-3. DESCRIPTION.

1-4. The Model 3406A Broadband Sampling Voltmeter is an easy-to-use high-frequency voltmeter incorporating an incoherent sampling technique for accurate measurements over a wide frequency range. Using the sampling technique, the accuracy of the Model 3406A is ±3% of full scale at frequencies between 100 kHz and 100 MHz, while the accuracy of measuring 700 MHz to 1 GHz signals is held to ±8% of full scale. Eight voltage ranges, selected by front panel pushbuttons, enable the 3406A to measure voltages from 1 mV to 3 volts full scale with 20 μV resolution on the 1 mV range. Sensitivity is high enough to detect a voltage change as small as 50 μV.

1-5. The meter features two easy-to-read linear voltage scales (0 to 1 and 0 to 3) calibrated in the rms value of a sine wave, and a dBm scale of -12 to +3 reference to 50 ohms. (Zero dBm is equal to one milliwatt dissipated across 50 ohms). Each range is calibrated in 10 dBm steps for power or gain measurement from -62 to +23 dBm in a 50 ohm system. The meter movement is individually calibrated and average-responding on all ranges. An overload circuit within the voltmeter protects the meter movement and internal circuits during an overload on any range. Recovery time after an overload is < 5 sec.

1-6. The input impedance of the Model 3406A depends upon the accessory probe tip used, and the frequency of the signal being measured. Typically, the input impedance is 100K ohms at 100 kHz in parallel with 2 pF. With the Isolator Tip, 11072A, used to eliminate the effect of source resistance, the total input shunt capacitance is between 9 and 10 pF. Input impedance curves as well as frequency range and use of various probe tips are given in Section III of this manual.

1-7. The 3406A is equipped with a slenderized probe for ease of measurement. A pushbutton located on the probe case retains the meter deflection when depressed. This makes possible measurements in awkward positions where it is difficult for the operator to place the probe in the circuit under test and at the same time read the meter.

1-8. FRONT PANEL CALIBRATION.

1-9. The Model 3406A provides a means of "calibrating" and "zeroing" the voltmeter from the front panel with no external test equipment. With the probe inserted into the 1 VOLT receptacle on the front panel and the CAL pushbutton released (out) the instrument may be zeroed in the presence of an RF field. When the CAL pushbutton is depressed an internal calibrator voltage is provided at the 1 VOLT receptacle. This voltage is used as a reference to adjust the gain of the Signal Amplifier within the 3406A for a 1 volt deflection on the meter. Since the sampling efficiency of 3406A depends upon the probe tip used, the Signal Amplifier gain is adjusted, via the front panel CALIBRATE control, each time the probe tip is changed. Refer to Section III for front panel zero and calibrate procedures. Refer to Section IV for definition of sampling efficiency.

1-10. APPLICATION.

1-11. In addition to voltage or dBm measurements on the 3406A meter, two outputs are provided on the rear panel to extend the measuring capabilities and usefulness of the Model 3406A.

1-12. RECORDER OUTPUT.

1-13. The RECORDER OUTPUT on the rear panel provides a dc output proportional to meter deflection. The dc RECORDER OUTPUT is used to drive auxiliary equipment, record measurements on a dc recorder, or digital voltmeter or it may be used as a high frequency AC-to-DC converter. The RECORDER OUTPUT may also be used to control the output level of a broadband signal generator which has dc modulation capability by monitoring the generator output with the 3406A.

1-14. SAMPLE HOLD OUTPUT.

1-15. A SAMPLE HOLD OUTPUT is also provided at the rear of the instrument. A signal statistically equivalent to the input signal being measured is made available at this output. The frequency of the SAMPLE HOLD OUTPUT is within the audio spectrum, even for input signals up to 2 GHz. Examples of statistically equivalent signals are given in Figure 3-2.

1-16. True rms and peak voltage values, amplitude modulation envelopes, pulse height information, and probability density functions of broadband signals can be determined by observing the SAMPLE HOLD OUTPUT. Refer to Section III for additional information on sample hold output measurements and how to take them.

1-17. INSTRUMENT/MANUAL IDENTIFICATION.

1-18. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual or Manual Backdating Changes in Section VII will define differences between your instrument and the Model 3406A described in this manual.

1-19. If a letter prefixes the serial number, the instrument was manufactured outside the United States.

1-20. ACCESSORIES/EQUIPMENT SUPPLIED.

1-21. The accessories and equipment supplied with each Model 3406A are listed in Table 1-2.

1-22. ACCESSORIES AVAILABLE.

1-23. Accessories available to increase the test capabilities of the Broadband Sampling Voltmeter are described briefly in Table 1-3. The Model 3406A accessories are available in two accessory probe kits shown in Figures 1-2 and 1-3, however, each accessory may be purchased individually if desired. Contact your local -hp- Sales and Service Office for additional information (see Appendix B for office locations).

To select the proper probe tip or adapter for various measurements, refer to the typical impedance curves and frequency range data given in Section III.

Table 1-2. Accessories/Equipment Supplied

DESCRIPTION	PART NO.	QUANTITY
Isolator Probe Tip	11072A	1
Nut Driver	-hp- Part No. 8710-0084	1
Replacement Tips	-hp- Part No. 5020-0457	10
Ground Clips	-hp- Part No. 10213-62102	2
Ground Lead	-hp- Part No. 5060-4991	1
Power Cord	-hp- Part No. 8120-0078	1
Operating and Service Manual	-hp- Part No. 03406-90001	1
Operating Note (Red)	-hp- Part No. 7124-0339	1

Table 1-3. Accessories Available

MODEL	TITLE	PURPOSE
11061A	10:1 Divider	Decreases input sensitivity of Model 3406A by a factor of ten (maximum sensitivity with divider is 30 V full scale).
10218A	BNC Adapter	Permits connection of probe to female BNC connector. (May be used with Isolator Tip).
11063A	50 Ohm Tee	Permits monitoring of signal in 50 ohm system without disturbing the line or attenuating the signal on the line.
--	50 Ohm Termination	Terminates signals in a 50 ohm system (use with 50 Ohm Tee).
11073A	Pen-Type Isolator Note If 11073A is ordered individually only the alligator clip and a ground lead will be supplied with the order.	Permits the probe to be clipped on or connected to the point of measurement using one of the following accessories: 1. Alligator clip (5060-0416) 2. Pincer Jaw (5060-0417) 3. Pin Tip (5060-0418) 4. Hook Tip (5060-0419) 5. Spring Tip (5060-0420) 6. Banana Tip (1251-0013)

Table 1-3. Accessories Available (Cont'd)

MODEL	TITLE	PURPOSE
10219A	Type 874A Adapter	Permits connection of probe to Type 874 coaxial connection (manufactured by General Radio Co.) may be used with Isolator Tip.
10220A	Microdot Adapter	Permits connection of probe to Microdot connection (manufactured by Microdot, Inc.) may be used with Isolator Tip.
11064A	Basic Probe Kit (See Figure 1-2)	Includes: 11063A 50 Ohm Tee 50 Ohm Termination
		11061A 10:1 Divider 10218A BNC Adapter Bag of probe tips and ground leads
11071A	Complete Probe Kit (See Figure 1-3)	Includes: 11063A 50 Ohm Tee 50 Ohm Termination 11061A 10:1 Divider 10218A BNC Adapter 10219A Type 874A Adapter 10220A Microdot Adapter 11073A Pen type Isolator with alligator clip, piner jaw, and all accessory tips. Bag of probe tips and ground leads

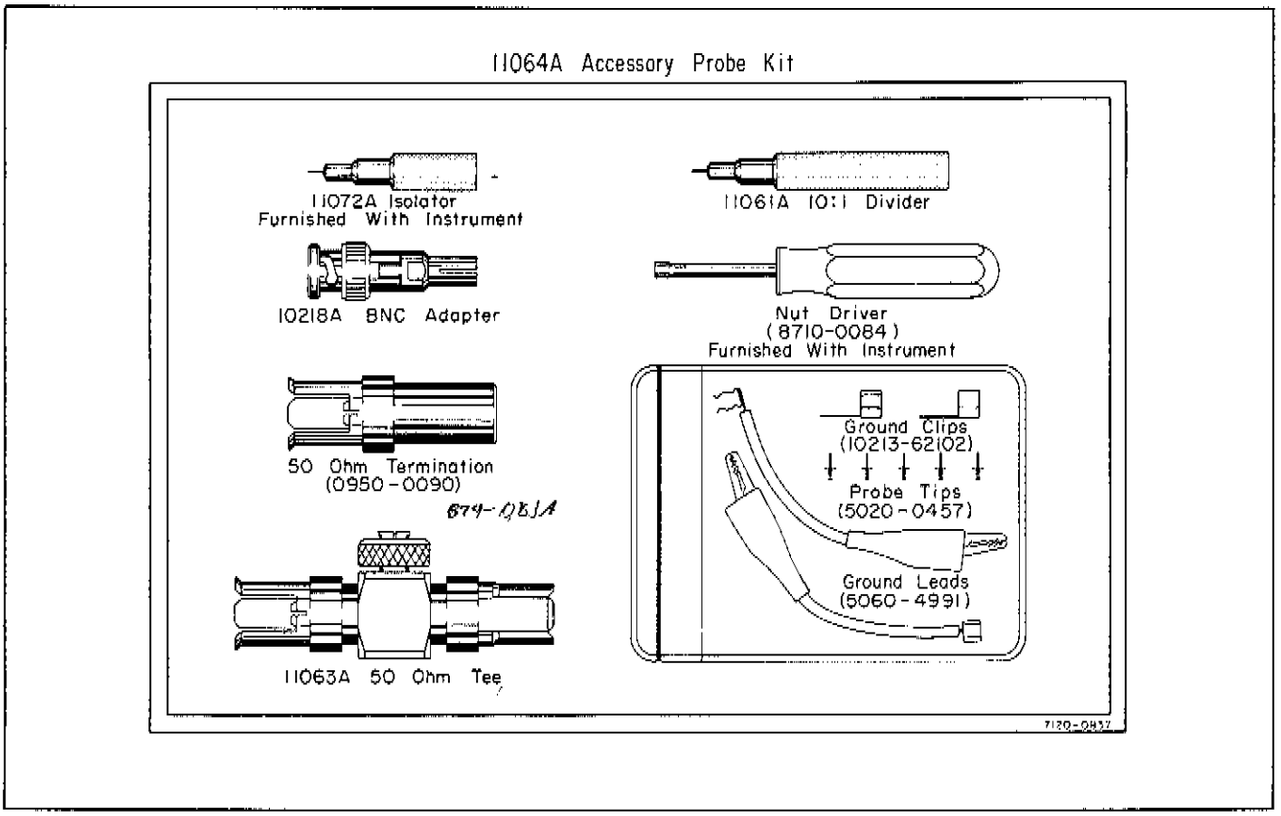


Figure 1-2. 11064A Basic Probe Kit

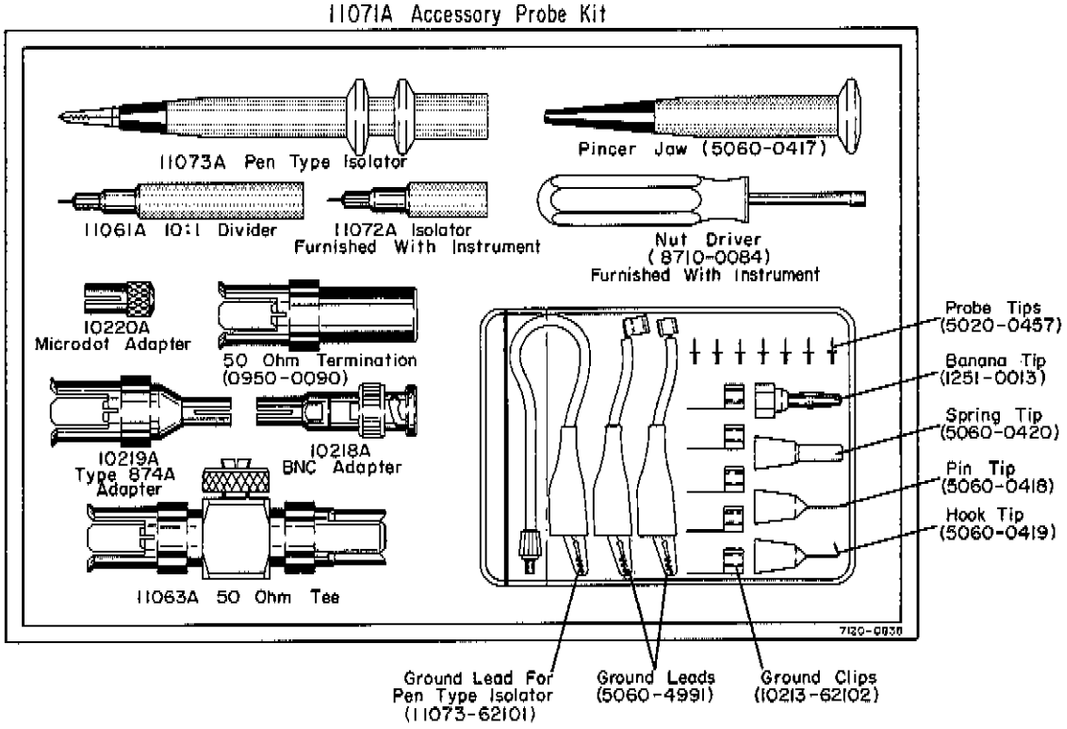


Figure 1-3. 11071A Complete Probe Kit

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary to prepare the Model 3406A Broadband Sampling Voltmeter for use. Included are initial inspection procedures, power and grounding requirements, installation information and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5, In-cabinet Performance Checks. If there is any physical damage or electrical deficiency, file a claim with the carrier, and refer to the warranty on the inside front cover of this manual. Should shipping of the instrument become necessary, refer to Paragraph 2-17 for repackaging and shipping instructions.

2-5. POWER REQUIREMENTS.

2-6. The Model 3406A requires either 115 or 230 volts ac ±10%, 50 to 1000 Hz and dissipates approximately 17 watts of power. With the instrument disconnected from the ac power source, slide the line voltage switch on the rear panel until the line voltage to be used appears and check the fuse for proper value (1/4 amp slow-blow for both 115 or 230 volt operation).

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers Association, (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the cabinet of the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 3406A is fully transistorized; therefore, no special cooling is required. The operating temperature range for the instrument cabinet is 0°C (32°F) to +55°C (131°F). The ambient temperature range of the probe is +10°C(50°F) to +40°C (104°F). The instrument, including probe, may be stored in temperatures between +60°C (141°F) and -40°C(-40°F).

2-12. The 3406A is assembled in a submodular unit suitable for bench top or rack-mounted operation. It is equipped with plastic feet and a metal tilt stand on the bottom for bench-top use. However, when used in combination with other submodular units, it can be bench and/or rack mounted. The Hewlett-Packard Combining Case and Rack Adapter Frame are designed for this purpose.

2-13. COMBINING CASE (-hp- Model 1051A or 1052A).

2-14. The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument. Filter Panels or an Accessory Drawer can be used in place of submodular units if desired.

2-15. RACK ADAPTER FRAME (-hp- Part No. 5060-0797).

2-16. The Rack Adapter Frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. Again, Filter Panels or an Accessory Drawer can be used in place of submodular units if desired. For additional information, contact your local -hp- Sales and Service Office (see Appendix B for office locations).

2-17. REPACKAGING FOR SHIPMENT.

2-18. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-19 if the original container is to be used; 2-20 if it is not. If you have any questions, contact your local -hp- Sales and Service Office.

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-19. If original container is to be used, proceed as follows:

a. Place instrument in original container with appropriate packing material if available.

A container and packing material can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that the container is well sealed with strong tape or metal bands.

2-20. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT," "FRAGILE" etc.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains instructions and information necessary for operation of the Model 3406A Broadband Sampling Voltmeter. Included are turn-on procedures, operating instructions, probe tip selection, and SAMPLE HOLD OUTPUT applications. Also included in this section is front panel ZERO and CALIBRATE procedures.

3-3. FRONT AND REAR PANEL CONTROLS, INDICATORS, AND CONNECTORS.

3-4. The function of the front and rear panel controls, indicators, and connectors is identified in Figure 3-1.

3-5. TURN-ON PROCEDURE.

3-6. To turn-on, zero and calibrate the Model 3406A, proceed as follows:

3-7. TURN-ON.

a. Position the Line Voltage Switch (12, Figure 3-1) on the rear panel to the source voltage to be used.

b. Depress the 1 volt RANGE Pushbutton (6) and verify that LINE indicator (2) lights.

3-8. ZERO.

a. With the CAL Pushbutton (8) released (out) insert probe with Isolator Tip (11072A) into the 1 VOLT receptacle (9).

b. Adjust ZERO control (5) for zero indication on Meter (3).

c. The zero adjustment for the upper five ranges (.03 to 3 volt range) may be performed on any one of the upper five ranges. On the .01, .003 and .001 volt ranges zero the voltmeter on the range selected prior to taking any measurements on that range.

NOTE

On the .001 volt RANGE, any difference between the ambient temperature of the circuit under test and the internal temperature of the 1 VOLT receptacle will affect the ZERO adjustment; therefore, perform the ZERO adjustment with the probe inserted into a terminated 50Ω tee, or perform the ZERO adjustment as rapidly as possible after inserting the probe into the 1 VOLT receptacle.

3-9. CALIBRATE.

a. With probe in 1 VOLT receptacle, (with Isolator Tip attached) depress CAL.

b. Adjust the CALIBRATE control (7) with a screwdriver for 1 volt indication on meter.

c. Remove probe from 1 VOLT Receptacle, and release CAL Pushbutton.

NOTE

Since the sampling efficiency of the 3406A voltmeter depends on the probe tip (accessory) used, the front panel "CALIBRATE" procedure is used to compensate the meter indication for the probe tip in use. Zero and calibrate the voltmeter each time the probe tip is changed or when just the bare probe is used with or without the 50Ω tee. Refer to Paragraph 3-27 for information on how to zero and calibrate the voltmeter per probe tip or adapter selected. Refer to Section IV for definition of sampling efficiency.

3-10. OPERATING INSTRUCTIONS.

3-11. The 3406A is designed to be used with either the Isolator Tip or one of the accessories available in the Base Probe Kit (11064A) or the Complete Accessory Kit (11071A). No other probe tip or probe kit is applicable. For proper selection of probe tip, refer to Table 1-3 and the frequency response and input impedance curves given in this section. All measurements require proper grounding of probe. Use one of the ground clips supplied with the 3406A or one of the ground leads in the Accessory Probe Kit. Connect the ground lead as close to the point of measurement as possible.

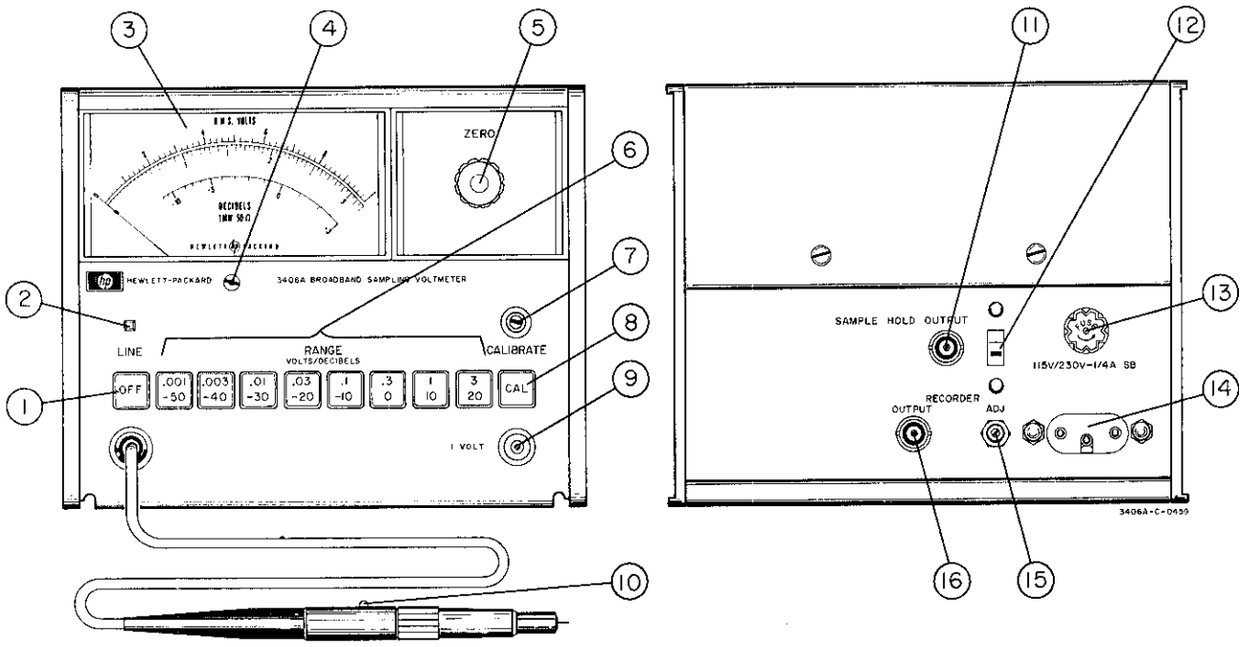
NOTE

For measurements where absolute accuracy is required, one of the following probe tips or adapters must be used:

11073A	Pen-Type Probe
11072A	Isolator Tip
11061A	10:1 Divider
11063A	50 Ohm Tee

For relative measurements with the same source resistance the bare probe may be used to achieve higher input impedance.

3-12. The maximum input voltage with any probe tip except the 10:1 divider is 15 V peak AC or 100 V DC. An AC Signal, up to 5 V peak, superimposed on a DC level of 100 V may be measured if desired.



(1) LINE OFF Pushbutton: disconnects ac operating power applied to instrument when depressed.

(2) LINE Indicator: illuminates when ac operating power is applied to instrument.

(3) Meter: indicates level of applied input signal in volts or dBm.

(4) Mechanical Zero Adjustment: screwdriver adjustment for mechanically zeroing of meter movement. (See Paragraph 5-19.)

(5) ZERO Control: provides variable control of zero offset on all ranges.

(6) RANGE Pushbuttons: applies ac operating power to instrument, and selects input voltage range.

(7) CALIBRATE Control: a screwdriver adjustment for calibrating the instrument per probe tip in use. (See note under Paragraph 3-9.)

(8) CAL Pushbutton: connects internal calibrator voltage to the 1 VOLT receptacle when depressed.

(9) 1 VOLT Receptacle: provides connections for probe, with or without probe tip, when zeroing or calibrating the instrument. (See Paragraphs 3-8 and 3-9.)

(10) Meter Hold Pushbutton: retains the meter indication when depressed.

(11) SAMPLE HOLD OUTPUT: provides connection for measuring peak and true rms value of input signal above 0.5 mv (see Paragraph 3-33 for application).

(12) Line Voltage Slide Switch: selects 115 or 230 vac source for the operating power of the instrument. Voltage selected appears on switch.

(13) FUSE: protects internal circuits of instrument (1/4 amp slow-blow for both 115 and 230 vac operation).

(14) Power Input Connector: connects ac operating power to instrument through power cord furnished with instrument.

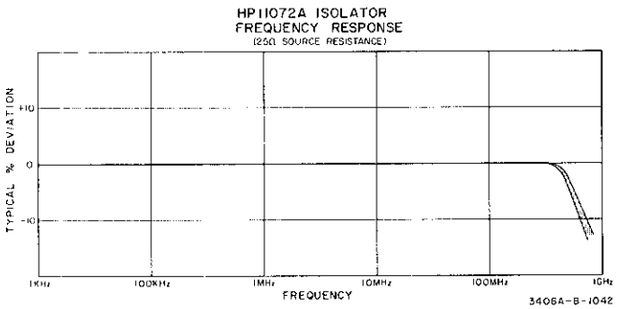
(15) RECORDER ADJ: screwdriver adjustment for varying the RECORDER OUTPUT between zero and 1.2 Ma into 1000 ohms at full scale.

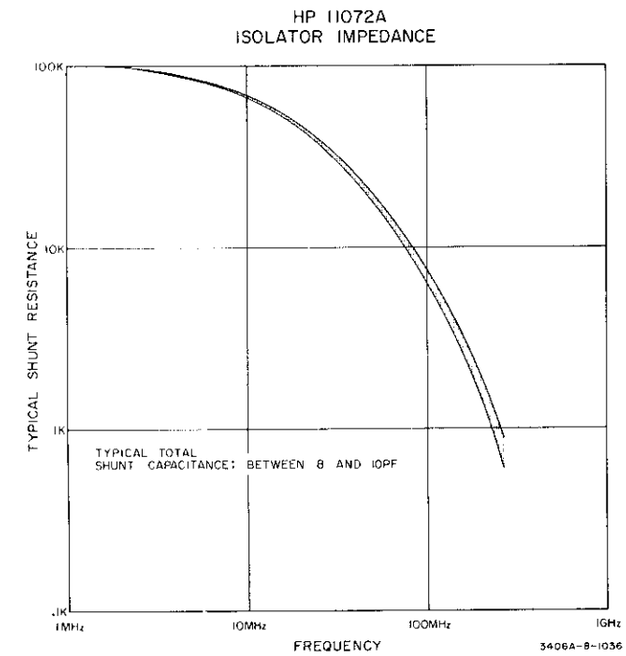
(16) RECORDER OUTPUT: provides a dc output proportional to meter deflection with full scale value determined by the RECORDER ADJ (15)

Figure 3-1. Front and Rear Panel Controls, Indicators and Connectors

3-13. 11072A ISOLATOR.

3-14. The 11072A Isolator essentially eliminates effects of source impedance variations. Total input capacitance with Isolator Tip is <10 pF. Recommended frequency range is 10 kHz to 250 MHz. The frequency response and input impedance with Isolator Tip is shown below. For explanation of why the Isolator Tip is necessary and how it works see Paragraph 4-14.





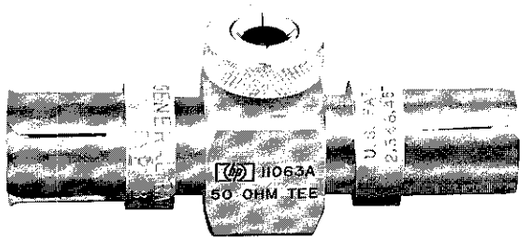
3-15. 11063A 50 OHM TEE.

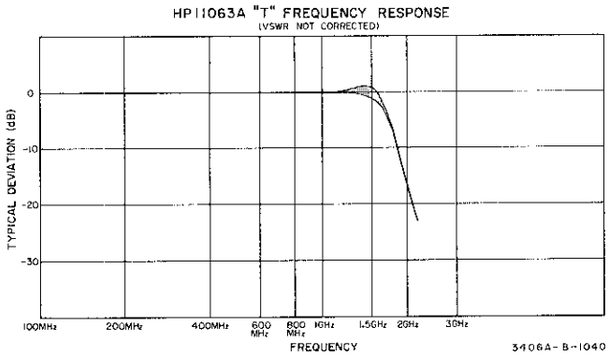
3-16. The 11063A tee is used whenever measurements are made in 50Ω systems.

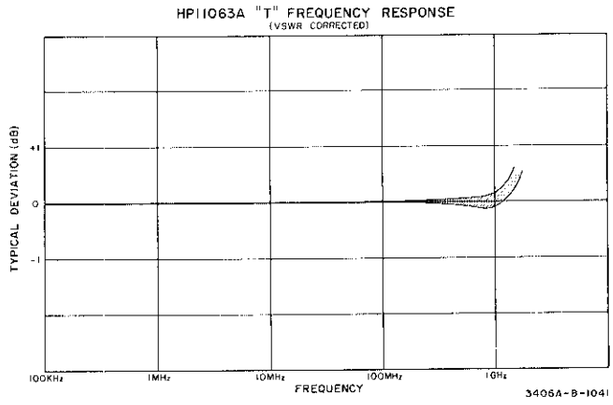
VSWR: < 1.15 up to 1 GHz (bare probe in tee)
Insertion Power Loss: < 4% up to 1 GHz

NOTE

The following curves apply only with the bare probe inserted in the tee. The frequency response of the tee with 10:1 divider is given in curve under Paragraph 3-18.





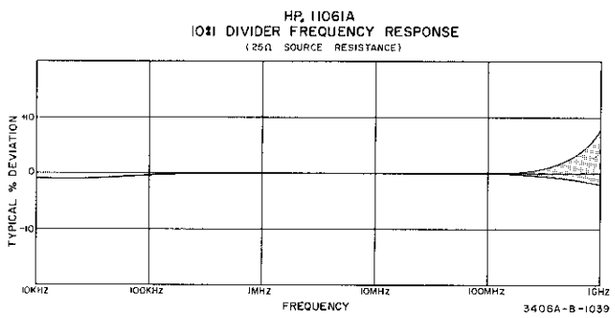


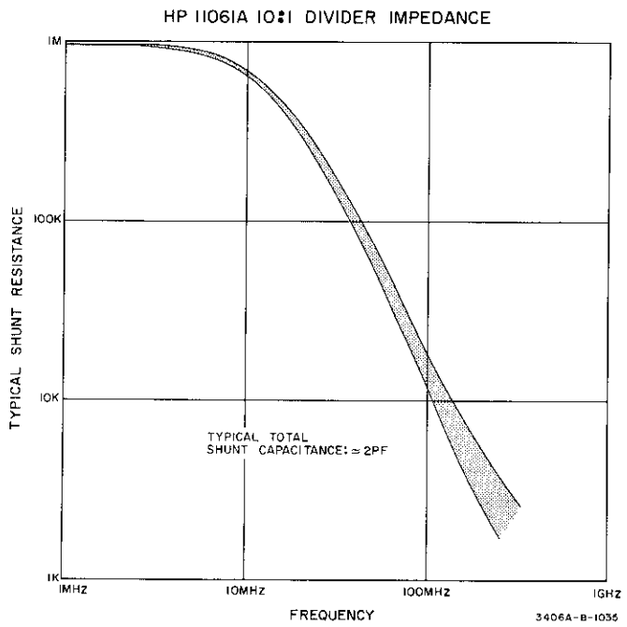
3-17. 11061A 10:1 DIVIDER.

3-18. The 11061A 10:1 Divider eliminates the effects of source impedance variations as well as divides the input voltage by a factor of ten.

Division Accuracy: ±5% 1 kHz to 400 MHz
±12% 400 MHz to 1 GHz

Max Input: 150 V pk-pk
600 Vdc





3-19. 11073A PEN TYPE ISOLATOR.

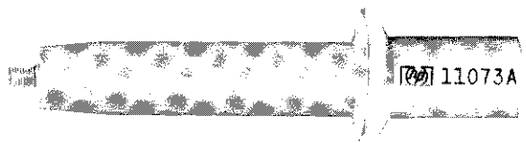
3-20. The 11073A Pen Type Isolator has a built in isolator to eliminate the effect of source impedance variations. Various attachments to the Pen Type Isolator facilitates point-to-point measurements. The recommended frequency range is 10 kHz to 50 MHz. The added input capacitance with Pen Type Isolator is less than 8 pF. One of the following accessory tips must be used with the Pen Type Isolator:

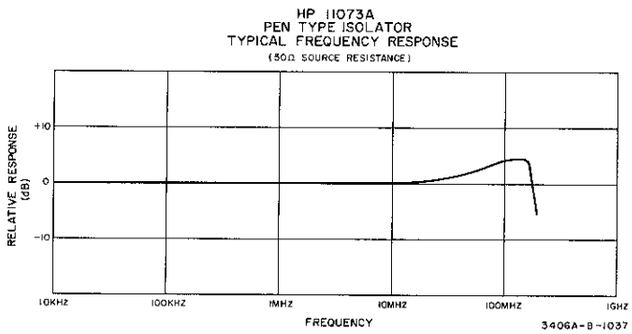
Alligator Clip
Pincer Jaw
Pin Tip
Hook Tip
Spring Tip
Banana Tip

} See Figure 1-3

NOTE

Use the alligator clip to ZERO and CALIBRATE the voltmeter when the Pen Type Isolator is used. After performing the ZERO and CALIBRATE procedure with the alligator clip any one of the six Pen Type Isolator accessories identified above may be used.



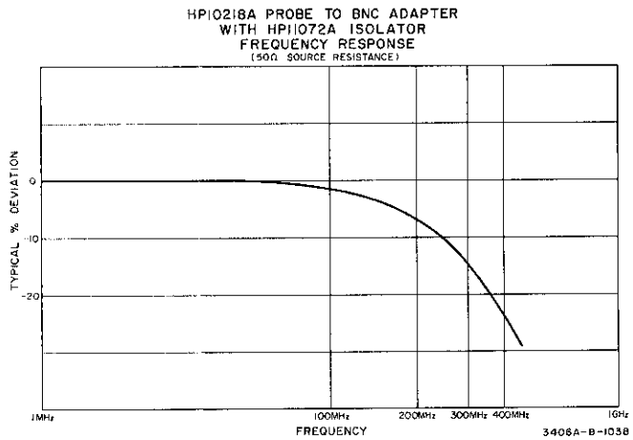


NOTE

Remove the plastic insulator on the front of the probe before attaching the Pen Type Isolator.

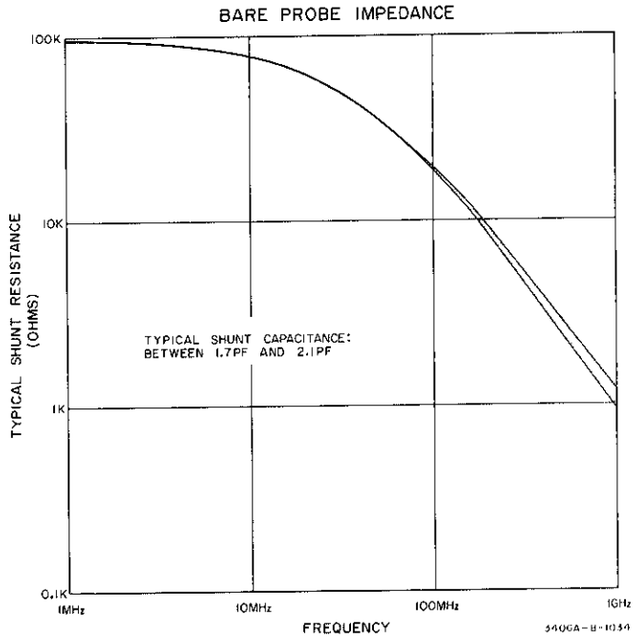
3-21. 10218A PROBE TO MALE BNC ADAPTER.

3-22. The 10218A Adapter is used to connect the probe to a female BNC connector. The recommended frequency range is 10 kHz to 250 MHz. To eliminate the effect of source impedance variations the Isolator Tip (11072A) is used with the Probe-to-BNC Adapter. The frequency response of the 10218A Adapter with the Isolator Tip is shown below.



3-23. THE BARE PROBE.

3-24. The bare probe may be used for relative measurements with same source resistance. For example, checking the frequency response of a tuned tank circuit or the gain of IF stage. A higher input impedance is obtained with the bare probe.



CAUTION

TO PROTECT THE PROBE TIP, WHEN THE INSTRUMENT IS NOT IN USE, INSERT THE PROBE INTO THE 1 VOLT RECEPTACLE WITH THE CAL PUSHBUTTON RELEASED.

3-25. PROBE TIP REPLACEMENT.

3-26. When replacing the probe tip on the bare probe, use the nut driver (-hp- Part No. 8710-0084) furnished with the instrument. Additional probe replacement tips may be purchased under -hp- Part No. 5020-0457.

CAUTION

WHEN REPLACING THE PROBE TIP DO NOT APPLY EXCESSIVE TORQUE; OTHERWISE DAMAGE TO COMPONENTS WITHIN THE PROBE ASSEMBLY WILL RESULT.

3-27. ZERO AND CAL THE PROBE TIP ACCESSORIES.

3-28. After selecting the proper probe tip, it is necessary to compensate the meter indication to the probe tip by performing the following procedure per probe tip or adapter selected.

a. 11063A 50 Ohm Tee: When the 50 Ohm Tee is used, remove the Isolator Tip (11072A) and perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 with the bare probe inserted into the 1 VOLT receptacle. After performing the ZERO and CALIBRATE procedures, connect the 50 Ohm Tee into circuit to be measured, and insert the bare probe into the 50 Ohm Tee. The 50 Ohm Termination (-hp- Part No. 0950-0090) is used to terminate the Tee into 50 ohms.

b. 11061A 10:1 Divider Tip: When using the 10:1 Divider Tip, remove the Isolator Tip (11072A) and perform the ZERO and CALIBRATE procedures, outlined in Paragraphs 3-8 and 3-9, with the 10:1 Divider Tip attached to the probe, and the 0.1 volt RANGE pushbutton depressed.

c. 10218A BNC Adapter: The BNC Adapter is used in conjunction with the Isolator Tip (11072A). Perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 before attaching the BNC Adapter to the Isolator Tip.

d. 11073A Pen-Type Probe: The Pen-Type Probe has a built in isolator. To ZERO and CALIBRATE the Pen-Type Probe, perform the steps outlined in Paragraphs 3-8 and 3-9 with the alligator clip attached to the Pen-Type Probe. After performing the ZERO and CALIBRATE procedures with the alligator clip, any one of the six pen probe attachments identified below may be used.

1. Alligator Clip
2. Pincer Jaw
3. Pin Tip
4. Hook Tip
5. Spring Tip
6. Banana Tip

e. 10219A Type 874A Adapter: The Type 874A Adapter is used in conjunction with the Isolator Tip (11072A). Perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 before attaching the Type 874A Adapter to the Isolator Tip.

f. 10220A Microdot Adapter: The Microdot Adapter is used in conjunction with the Isolator Tip (11072A). Perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 before attaching the Microdot Adapter to the Isolator Tip.

3-29. METER HOLD.

3-30. The Meter Hold Pushbutton (10) located on the Probe Assembly retains the meter indication for a minimum of 15 seconds when depressed. The meter Hold Pushbutton is used when making measurements in an awkward position where it is difficult to place the probe in the circuit under test and at the same time read the meter indication.

3-31. APPLICATIONS.

3-32. The Model 3406A Broadband Sampling Voltmeter is equipped with a RECORDER and SAMPLE HOLD OUTPUT in addition to the average responding direct reading rms meter. A few applications of both the RECORDER and SAMPLE HOLD OUTPUT are listed in the following paragraphs.

3-33. SAMPLE HOLD OUTPUT.

3-34. The SAMPLE HOLD OUTPUT is located on the rear panel of the instrument. A signal statistically equivalent to the input signal being measured is made available at this output. The frequency of the SAMPLE HOLD OUTPUT is within the audio spectrum, even for input signals above 2 GHz. Examples of statistically equivalent signals for three separate input signals are illustrated in Figure 3-2.

3-35. The accuracy of the SAMPLE HOLD OUTPUT is the same as the full-scale accuracy of the meter indication on the 0.01 V RANGE and above. On the 0.001 V or 0.003 V RANGE the value of input signal can be computed by taking into account the residual noise of the instrument as outlined in Paragraph 3-36 step c.

3-36. When using the SAMPLE HOLD OUTPUT the following conditions must be observed:

a. The crest factor of the input signal must not exceed 20 dB (10:1) on the 0.001 to 0.3 volt RANGE, 13 dB (4.46:1) on the 1 VOLT RANGE, and 3 dB (1.41:1) on the 3 VOLT RANGE.

b. The SAMPLE HOLD OUTPUT is valid only when the probe is connected to the circuit under test. The Meter Hold Pushbutton has no effect on the SAMPLE HOLD OUTPUT.

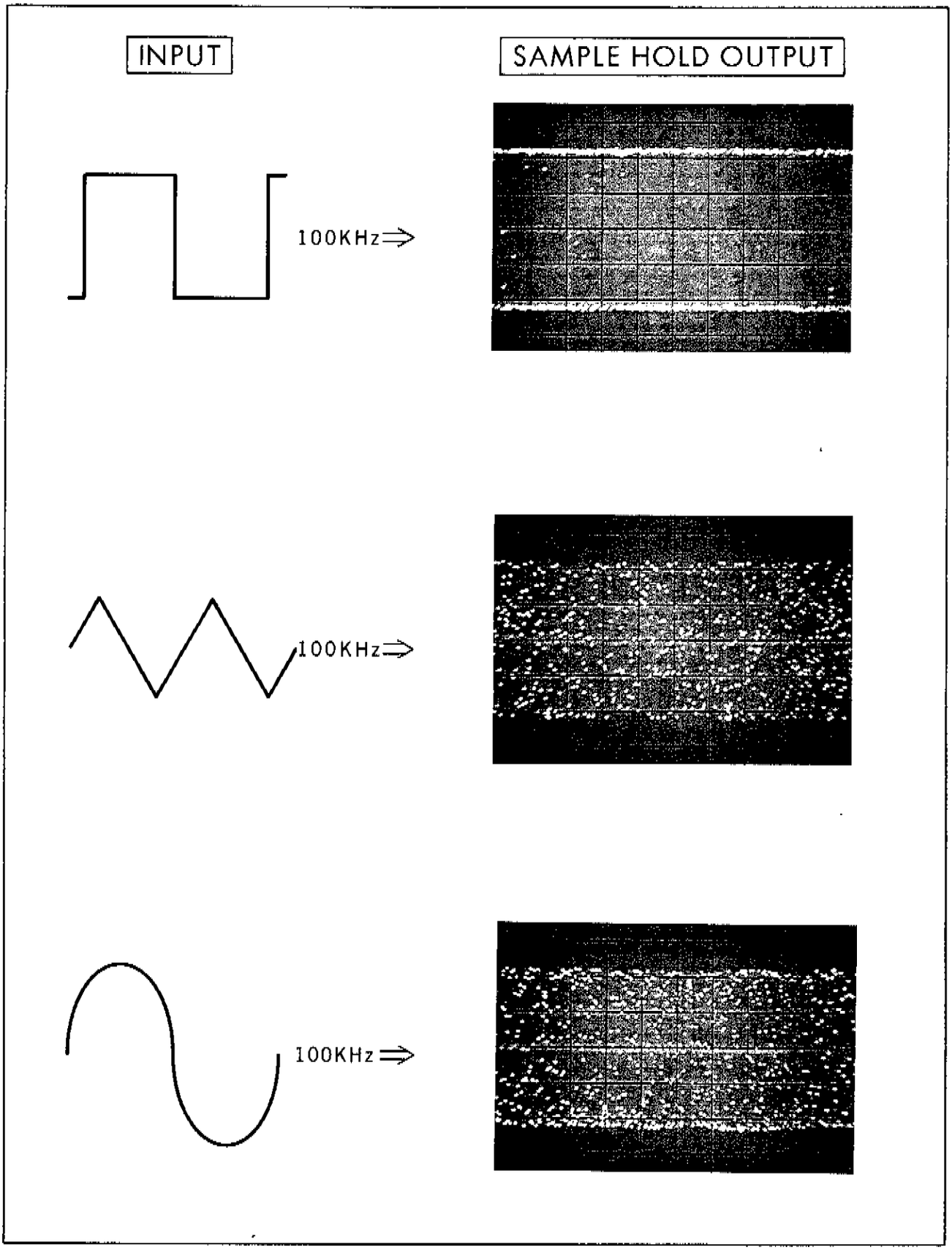


Figure 3-2. Statistically Equivalent Signals

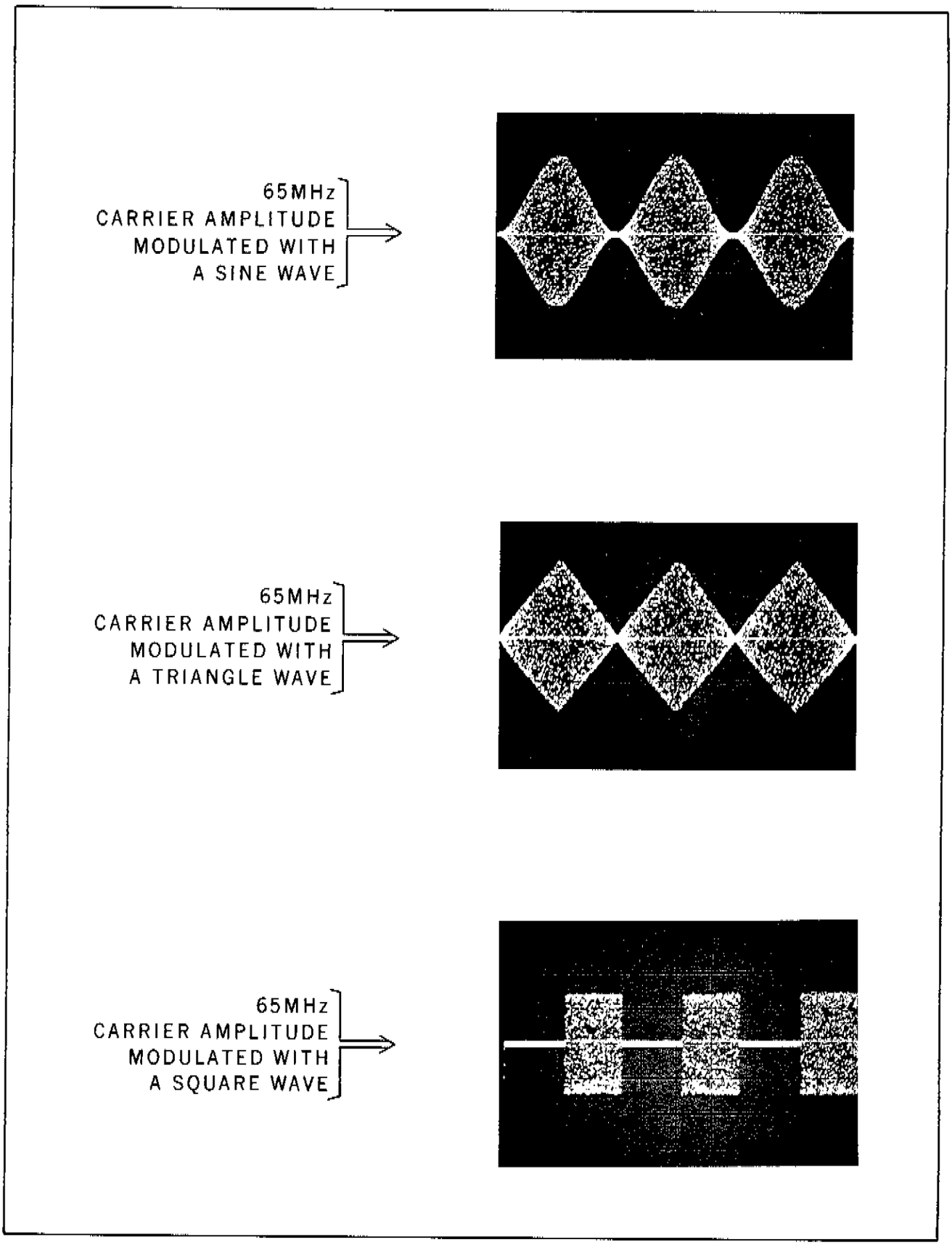


Figure 3-3. Amplitude Modulated Signals

c. When using the SAMPLE HOLD OUTPUT to measure true rms on the .003 or .001 volt RANGE, it becomes necessary to calculate the true rms value of the input signal because of the noise present on the .003 or .001 volt RANGE using the following formula:

$$E_{rms} = \sqrt{E_s^2 - E_n^2}$$

where: E_n = Noise measured on the 3400A connected to the SAMPLE HOLD OUTPUT with the 3406A input shorted to ground and RANGE set on .003 or .001 volts.

NOTE

To ground the 3406A input, insert the probe into the 1 VOLT receptacle with the CAL pushbutton released.

E_s = 3400A indication with the input signal to be measured applied to the 3406A input.

3-37. SAMPLE HOLD OUTPUT MEASUREMENTS.

a. True RMS Measurements:
The SAMPLE HOLD OUTPUT may be used to measure the true rms value of the input signal on a True RMS Voltmeter such as the Hewlett-Packard Model 3400A. A true rms measurement may be made on any recurring waveforms within the frequency range of the Model 3406A.

NOTE

The SAMPLE HOLD OUTPUT voltage is always 0.316 volts at full-scale on all ranges because of the location of the SAMPLE HOLD OUTPUT terminal in the 3406A (refer to Block Diagram, Figure 4-4). Therefore, set the voltmeter connected to the SAMPLE HOLD OUTPUT on the 0.3 volt range and use the RANGE setting of the 3406A to determine the proper reading of the voltmeter attached to the SAMPLE HOLD OUTPUT. For example, with the 3406A indicating full scale on the 1 volt RANGE, with a sine wave input, the 3400A True RMS Voltmeter will indicate (1 volt) full-scale only on the .3 volt range.

b. Peak or Peak-to-Peak Measurements:
The SAMPLE HOLD OUTPUT may be used to measure the peak or peak-to-peak value of the input signal on a low frequency oscilloscope such as the Hewlett-Packard Model 130C.

NOTE

The SAMPLE HOLD OUTPUT voltage is always 0.316 volts at full-scale on all ranges because of the location of the SAMPLE HOLD OUTPUT terminal. Therefore, to determine the proper peak or peak-to-peak value of the input signal on an oscilloscope, use the settings identified in Table 3-1.

c. Recovering Amplitude-Modulated Signals:
The SAMPLE HOLD OUTPUT may be used to monitor an AM signal with a carrier frequency within the frequency range of the 3406A, and a modulation frequency of DC to 1 kHz. Using this application hum modulation on a RF carrier may be observed. Examples of the SAMPLE HOLD OUTPUT for amplitude modulated signals are illustrated in Figure 3-3.

Table 3-1. Oscilloscope Settings

3406A RANGE	SAMPLE HOLD OUTPUT (full-scale)	Oscilloscope Vert. Sensitivity	
		Actual Setting	With Respect to Input Signal
3 Volt	0.316 Volts	.1 V/cm	1 V/cm
1 Volt	0.316 Volts	.1 V/cm	.33 V/cm (3 cm = 1 V)
.3 Volt	0.316 Volts	.1 V/cm	.1 V/cm
.1 Volt	0.316 Volts	.1 V/cm	.033 V/cm (3 cm = .1 V)
.03 Volt	0.316 Volts	.1 V/cm	.01 V/cm
.01 Volt	0.316 Volts	.1 V/cm	3.3 mV/cm (3 cm = .01 V)
.003 Volt	0.316 Volts	.1 V/cm	1 mV/cm
.001 Volt	0.316 Volts	.1 V/cm	.3 mV/cm (3 cm = .001V)

d. Measure true rms value of ac signal with dc component:
Since the 3406A is an ac device the SAMPLE HOLD OUTPUT can be used to measure only the rms value of the ac component. If it is necessary to include the rms value of the dc component when measuring a signal use the following formula:

NOTE

The frequency of the ac signal must be within the frequency range of the 3406A, and the dc component level must not exceed 100 Vdc.

$$E_{rms} = \sqrt{E_{ac}^{2} + E_{dc}^{2}}$$

E_{ac} = SAMPLE HOLD OUTPUT voltage measured with 3400A.

E_{dc} = The dc component measured with the -hp- Model 414A, DC Voltmeter.

3-38. RECORDER OUTPUT.

3-39. The RECORDER OUTPUT on the rear panel provides a dc output proportional to meter deflection. The output current level is variable between zero and 1.2 ma into 1000 ohms at full scale. The output level is controlled by the RECORDER ADJ on the rear panel.

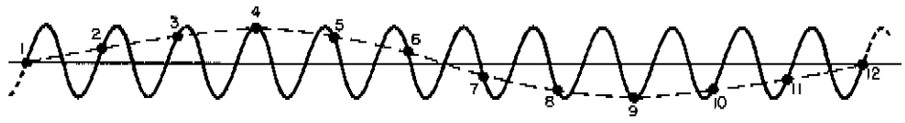
3-40. RECORDER OUTPUT APPLICATIONS.

3-41. The RECORDER OUTPUT is used to record measurements or drive auxiliary equipment. Two applications are as follows:

a. High frequency AC-to-DC converter:
The RECORDER OUTPUT may be used as an AC-to-DC converter for ac signals from 10 kHz to 2 GHz.

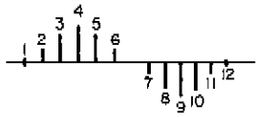
b. Leveling:
The RECORDER OUTPUT may be used to control the output level of a broadband signal generator which has a dc modulation capability and the necessary loop compensation circuits to prevent oscillations.

A



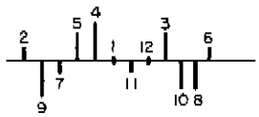
Input signal being sampled coherently

B



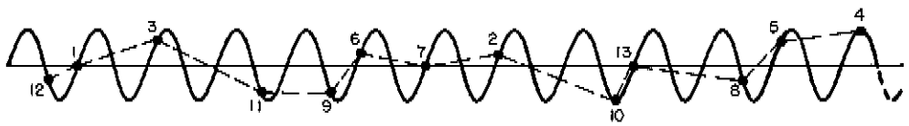
A collection of pulses reconstructing a low frequency equivalent of the input signal by preserving the height, polarity and relative phase of each sample taken.

C



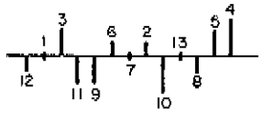
A collection of pulses "scrambled" with only the height and polarity preserved will have the same average, peak and rms values as waveform B.

D



Input signal being sampled in an incoherent fashion

E



A collection of pulses representing the polarity and height of each sample taken incoherently. The average, peak and rms values of this waveform are the same as waveform C and B.

3406A-RG

Figure 4-1. Sampling Technique

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the theory of operation for the -hp- Model 3406A Broadband Sampling Voltmeter. A discussion of the sampling technique used as well as a theory of operation is given.

4-3. SAMPLING TECHNIQUE.

4-4. The -hp- Model 3406A uses a unique "incoherent" sampling technique to translate a high frequency input signal into a low frequency equivalent. This incoherent sampling used to produce the equivalent signal is illustrated in Figure 4-1 and described in the following paragraphs.

4-5. COHERENT SAMPLING.

4-6. Waveforms A and B in Figure 4-1 illustrate the coherent sampling technique commonly used in oscilloscopes to reconstruct the waveform at a lower frequency. With coherent sampling each sample is taken at a fixed frequency with the period of time between samples remaining constant as illustrated in waveform A.

4-7. Waveform B is a collection of pulses representing each sample (1 thru 12) taken on waveform A. The relative phase (order), polarity and proportional amplitude of the input signal at the point of sample are all preserved. Therefore, if a sufficient number of samples are taken a lower frequency equivalent of the input signal will be reconstructed. This lower frequency equivalent will have the same average, peak and rms value as the original signal, waveform A.

4-8. INCOHERENT SAMPLING.

4-9. If the pulses in waveform B were "scrambled" with only the amplitude and polarity preserved a pulse train similar to waveform C may result. The pulses in waveform C, having no phase relationship with the input signal will not reconstruct the input waveform, but the statistical properties (average, peak and rms) of waveform C will be the same as waveform B. The statistical properties are the same because the same pulses are used in both waveforms. The only thing different is the order. Therefore, if a sufficient number of samples were taken in this "scrambled" fashion the resulting pulses would be statistically equivalent to the input signal with the only relative phase relationship lost.

4-10. As shown in waveform C the relative phase does *not* affect the statistical properties of the reconstructed pulse train; therefore, the 3406A can use a sampling technique where only the polarity and amplitude of each sample is used to determine the value of the input signal. This sampling technique is referred to as "incoherent sampling." With incoherent sampling, the interval between samples does not remain constant and the relative phase between each sample is lost as illustrated in waveforms D and E. However, the polarity and proportional amplitude of the input signal at the point of sample are still preserved; therefore, if a sufficient number of incoherent samples are taken, the average, peak and rms values of the reconstructed pulse train will be statistically equivalent to the input.

4-11. In the 3406A this statistically equivalent pulse train is amplifier and applied to the SAMPLE HOLD OUTPUT for true rms or other types of measurements. The same statistically equivalent pulse train is also detected and applied to the meter circuit for a meter indication. With this reconstructed pulse train applied to the meter circuit, a small amount of meter jitter shows up. This is because the accuracy of reconstructing the input signal is proportional to number of samples taken. If an infinite number of samples could be taken, then the representation (reconstruction) of the input would be identical to the input. This, however, is impractical. Therefore, due to the finite sample rate (between 10 and 20 thousand per second) of the 3406A, there will be small movements of the meter needle (jitter) over a period of time.

4-12. WHY INCOHERENT SAMPLING.

4-13. The 3406A uses incoherent sampling to avoid difference frequencies within the passband (0 to 10 Hz) of its metering circuit. These difference frequencies or "beat signals" could arise if the sampling frequency is held constant. For example, if the sampling frequency of the 3406A was held constant, say 10 kHz, thousands of points (frequencies) within the bandwidth of the 3406A would be harmonics of the sampling frequency. If one of these harmonics became the input signal to be measured all the samples would have exactly the same amplitude and the 3406A would see only one amplitude and one polarity (a beat signal) making it impossible to reconstruct an equivalent signal. To avoid this number in the 3406A, the sampling frequency is varied between 10 kHz and 20 kHz to produce "incoherent" sampling of the input signal.

4-14. SAMPLING EFFICIENCY.

4-15. The sampling efficiency of the Model 3406A Voltmeter is determined by the source impedance of the signal being measured or the probe tip being used. Figure 4-2, illustrating the Sampling Probe Assembly A1, a source impedance Rs and a source voltage Vs, is used to explain sampling efficiency.

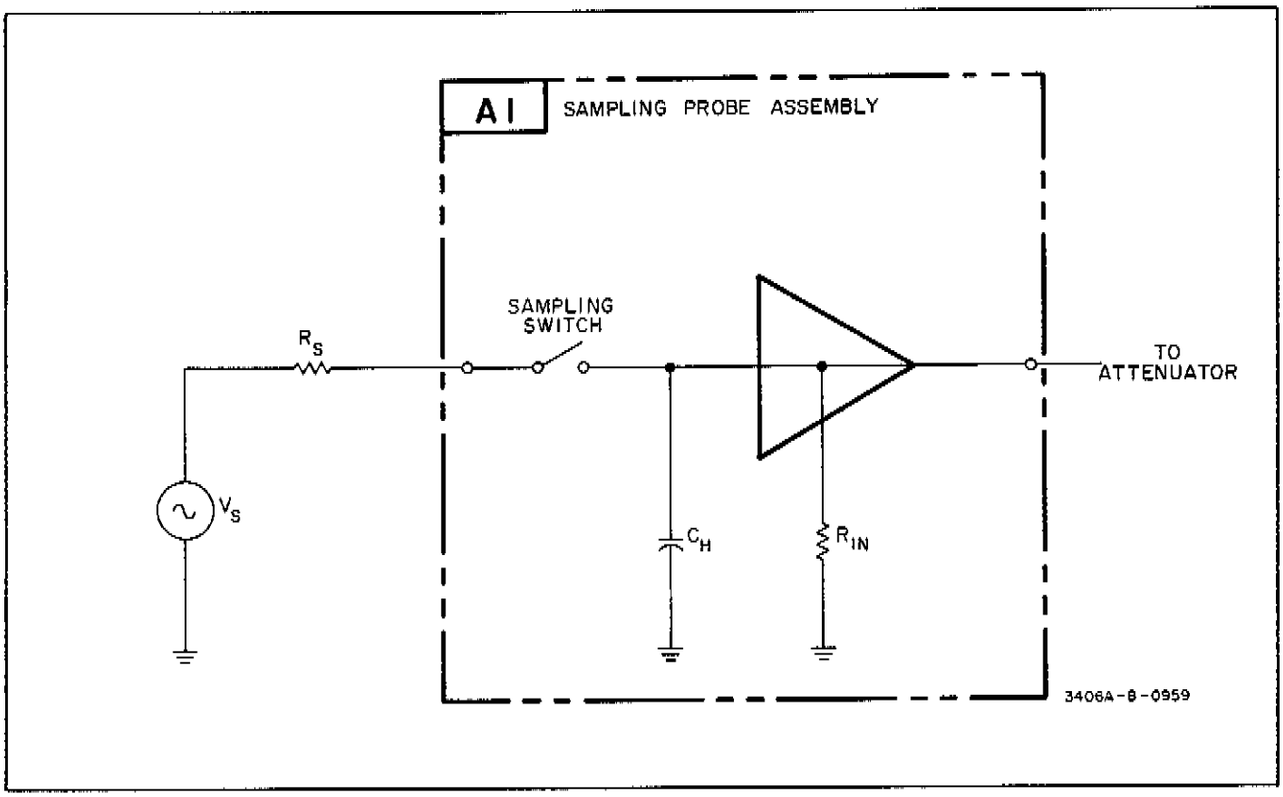


Figure 4-2. Sampling Probe Assembly

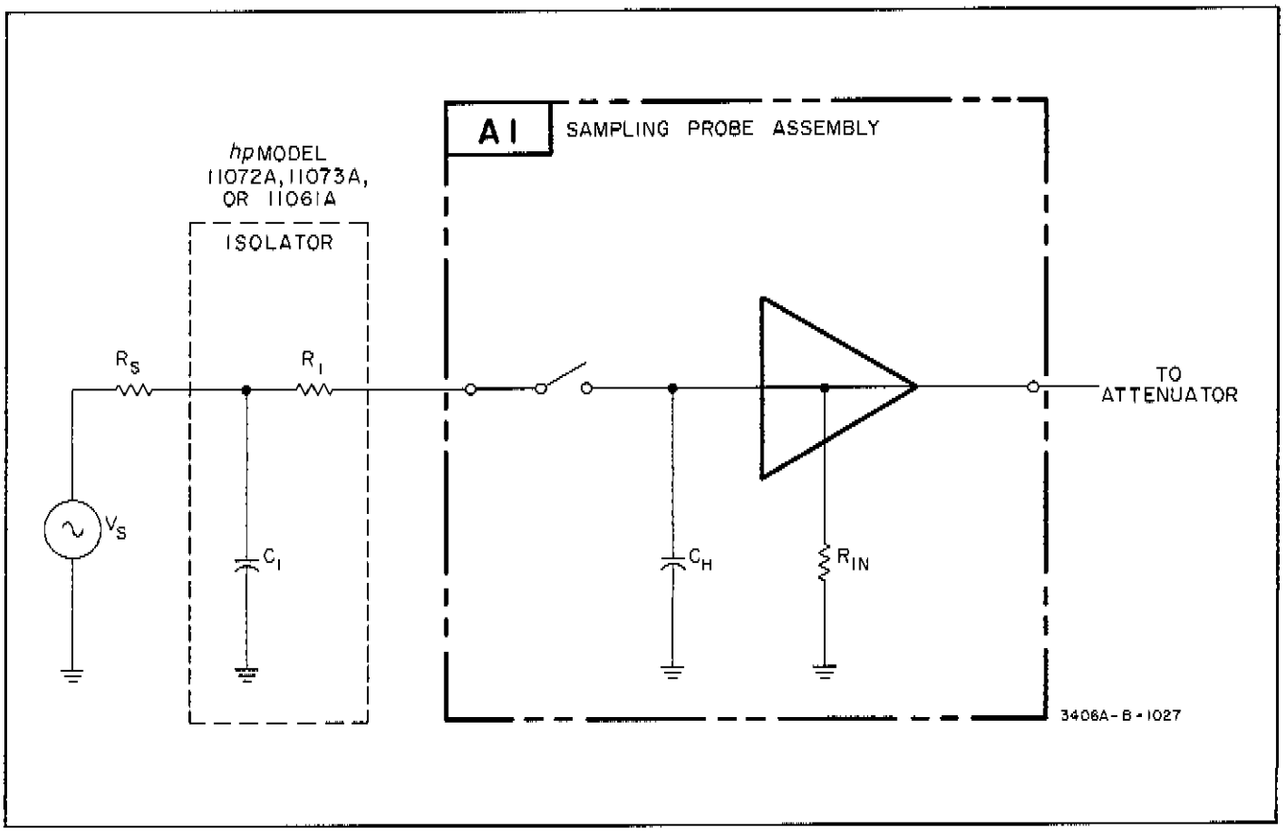


Figure 4-3. Function of Isolator Tip

4-16. A switch within the sampling probe assembly closes for a very short period of time during each sample. When the switch closes, Holding Capacitor, C_h, will start to charge through the source resistance R_S to a value proportional to the source voltage V_S. A measurement of how close the charge on the holding capacitor C_h comes to the actual input voltage is referred to as "sampling efficiency". Therefore, sampling efficiency, in percent, can be defined by following formula:

$$\text{Sampling Efficiency} = \frac{V_c}{V_S} \times 100$$

Where: V_c = Charge developed on capacitor during the time the switch is closed.

V_S = Actual input voltage of the source.

4-17. Since the period of time that the sampling switch remains closed is fixed (between 200 and 300 picoseconds), the source resistance R_S is the only factor determining the sampling efficiency when only the bare probe is being used. The higher the source resistance the less the charge on the holding capacitor C_h and consequently the lower the sampling efficiency. With a smaller source resistance the time constant of R_S and C_h is faster and the charge on C_h comes closer to the total source voltage V_S, and the sampling efficiency goes up. Since the charge on C_h is directly proportional to the meter deflection and SAMPLE HOLD OUTPUT level, the absolute accuracy of the voltmeter becomes a function of the sampling efficiency. This effect of source resistance on the sampling efficiency of the voltmeter is the reason that the bare probe can only be used for relative measurements with constant source resistance.

4-18. To maintain a constant sampling efficiency and eliminate the effect of varying source impedance various "isolator tips" such as the 11072A Isolator Tip, the 11073A Pen Type Isolator, the 11061A 10:1 Divider or the 50 Ω Tee may be attached to the bare probe. These isolators compensate the effect source resistance by inserting a resistor R_1 and capacitor C_1 before the sampling switch as illustrated in Figure 4-3. For high source resistance (large TC for $R_S - C_h$) the isolator puts a capacitor C_1 in parallel to aid the charge on holding capacitor C_h by discharging when the switch closes. For low source resistance (small TC for $R_S - C_h$) the isolator has a series resistor R_1 to increase the time constant and prevent raising the percentage of charges on holding capacitor C_h. Both C_1 and R_1 within the isolators are selected at the factory to give a constant sampling efficiency over a wide range of source impedance. However, since the physical size and value of R_1 and C_1 varies between the 11072A Isolator Tip, the 11073A Pen Type Isolator and the 11061A 10:1 Divider, the actual sampling efficiency depends on the type of isolator used. For this reason a means of compensating for the difference in sampling efficiency between isolator tips is provided on the front panel.

4-19. Front panel calibrate procedure outlined in Section III adjusts the gain of the Signal Amplifier (A2Q2 thru A2Q6) to compensate for the difference in sampling efficiency between the types of isolator tips used. This is the reason the front panel CALIBRATE control must be adjusted each time a different probe tip is selected. Also, since the sampling efficiency of the bare probe is different than any one of the isolators, it becomes necessary to "recalibrate" the voltmeter with just the bare probe before inserting it into the 50 Ω Tee.

4-20. GENERAL THEORY OF OPERATION.

4-21. Figure 4-4 is a block diagram illustrating the Model 3406A Broadband Sampling Voltmeter operation. All blocks shown in Figure 4-4 except the Sampling Probe Assembly and Range Control are located on two etched circuit boards (top and bottom assemblies) inside the modular cabinet of the instrument. The Sample Probe Assembly is physically located within the probe. The Range Control consists of the front panel RANGE pushbuttons and associated resistors.

4-22. Instead of continuously monitoring the input, as other RF voltmeters do, a series of samples are taken by the Sampling Probe Assembly and reconstructed into a statistical equivalent pulses train.

4-23. The input signal to be measured is applied through the appropriate probe tip to a sampling switch (see Figure 4-2) within the Sampling Probe Assembly A1. The sampling switch closes to sample the input for 200 to 300 picoseconds. The rate of closing and opening the sampling switch is controlled by Sampler Drive Pulses from the Pulse Generator p/o A3. The Sampler Drive Pulse repitition rate varies between 10 kHz and 20 kHz at a 10 Hz rate, thus producing the incoherent sampling previously discussed.

4-24. A Triangle Wave Generator and a Voltage Controlled Oscillator (all p/o A3) are used to vary the pulse repetition rate of Sample Drive Pulse. A fixed 10 Hz triangle wave from the Triangle Wave Generator is applied to the Voltage Controlled Oscillator. The voltage level of the applied triangle wave determines the output frequency of the VCO. The peak (antinode) point of the triangle wave corresponds to a 10 kHz sawtooth output and the nodes (0 volts) corresponds to a 20 kHz sawtooth output. Therefore, the output of the VCO becomes a sawtooth sweeping between 10 kHz and 20 kHz at the rate of the applied triangle (10 Hz). This sweeping sawtooth is applied to the Pulse Generator where a Sampler Drive Pulse is generated for each sawtooth received. Since the sawtooth is sweeping between 10 kHz and 20 kHz at a 10 Hz rate the occurance of the Sampler Drive Pulse will also vary between 10 kHz and 20 kHz at the same rate.

4-25. The Sampler Drive Pulse closes the sampling switch, and the holding capacitor C_h (see Figure 4-2) charges to a voltage proportional to the input signal. When the sampling switch reopens, after each sample, the holding capacitor completely discharges. Each charge on holding capacitor is applied to the Attenuator

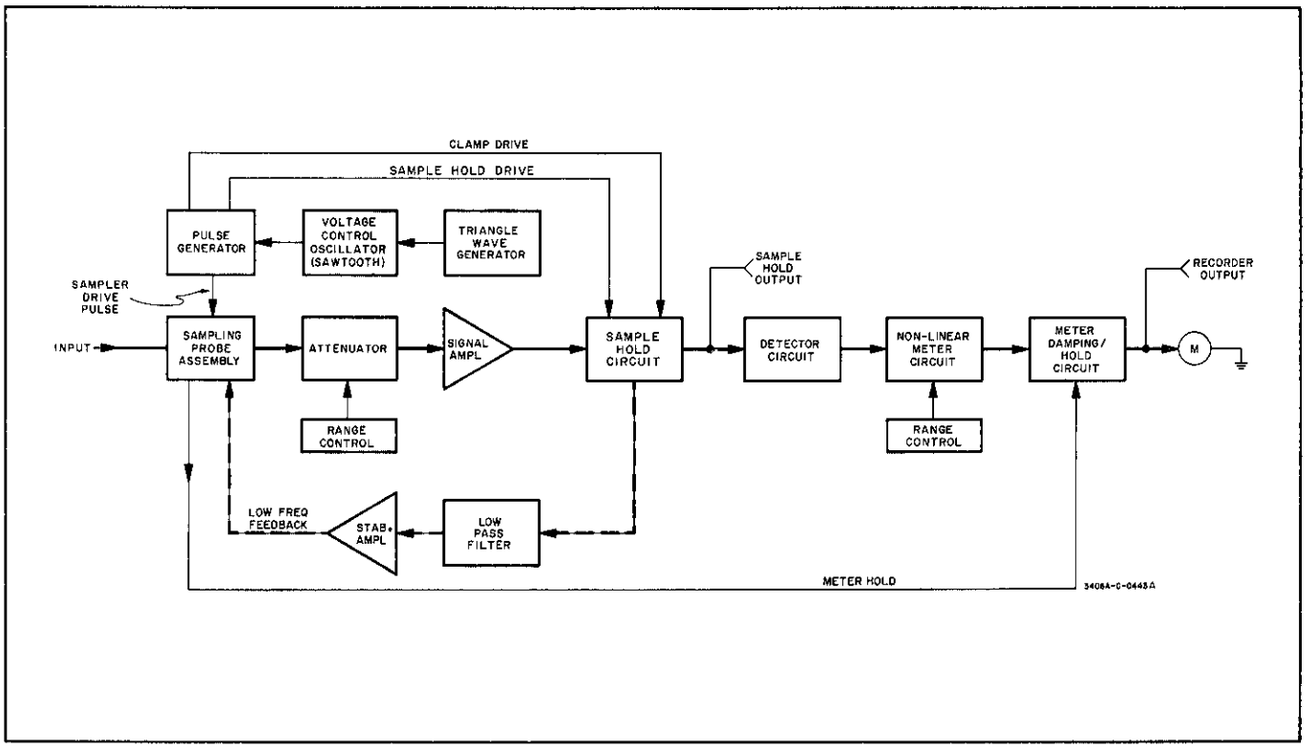


Figure 4-4. Block Diagram

illustrated in Figure 4-4. Thus the sampling probe output becomes a train of pulses (one pulse per sample) whose amplitudes are directly proportional to the amplitude of the input signal at the instant the samples are taken as illustrated in Figure 4-5 waveforms A and B.

4-26. The amount of attenuation is controlled by the front panel RANGE pushbuttons. After appropriate attenuation, the pulses are amplified by the Signal Amplifier (p/o A2). Since the input signal has been translated into a lower frequency equivalent no high frequency compensation circuits are required in the Signal Amplifier. Three pulses from the Signal Amplifier, representing three different samples taken, are shown in Figure 4-5 waveform D. After passing through the input cable and the Signal Amplifier the sample pulses become about 5 μs wide. Note, however, that the peak amplitudes of these pulses are proportional to the amplitude of the input signal at the point of sample. After the Signal Amplifier the pulses are applied to the Sample Hold Circuit.

4-27. Within the Sample Hold Circuit (p/o A2), the peak amplitude of each pulse from the Signal Amplifier is detected and held after a 2.5 μsec "clamping interval" as illustrated in Figure 4-5 waveform E. Note that the peak amplitude detected is held until the next sample is initiated.

4-28. The clamping interval is the period of time (2.5 μs immediately following each sample) during which the output of Sample Hold Circuit is clamped to zero volts. The clamping of each sample to zero volts establishes the dc reference level for the Signal Amplifier and the Sample Hold Output, as well as eliminating any transients that may have been caused by the Pulse Generator when the actual sample was taken.

4-29. The Clamp Drive signal from the Pulse Generator controls the starting and stopping of the clamping interval. The Clamp Drive signal is synchronized with the Sampler Drive Pulse sent to the sampling probe and occurs at the same time. Each Clamp Drive signal from the Pulse Generator, clamps the output of the Sample Hold Circuit to zero volts for 2.5 μsec. During this 2.5 μsec the maximum amplitude of the pulse from the signal Amplifier is reached (detected) and held as shown in Figure 4-5. The peak or maximum amplitude reached is proportional to the amplitude of the input signal at the point of sample.

4-30. The Sample Hold Drive signal, also from the Pulses Generator, is the signal that enables the Sample Hold Circuit to detect the maximum amplitude of each pulse while the output is clamped to zero volts. The Sample Hold Drive signal is also synced with the Sampler Drive Pulse and occurs at the same time.

4-31. The Sample Hold Drive signal breaks down two zener diodes, A2CR1 and A2CR2 shown in Figure 4-6, each time a sample is taken. With the two diodes conducting in reverse direction the respective pulse from the Signal Amplifier charges capacitor A2C12 to the peak value of the pulse during the 2.5 μs clamping interval. The charge on capacitor A2C12 remains at this peak value even after the Sample Hold Drive and the Clamp Drive Signals are removed. This is the reason for the term "Sample-Hold". Each sample pulse is actually held at its peak amplitude until the next sample is taken, and then the Sample Hold Output is again clamped back to zero volts.

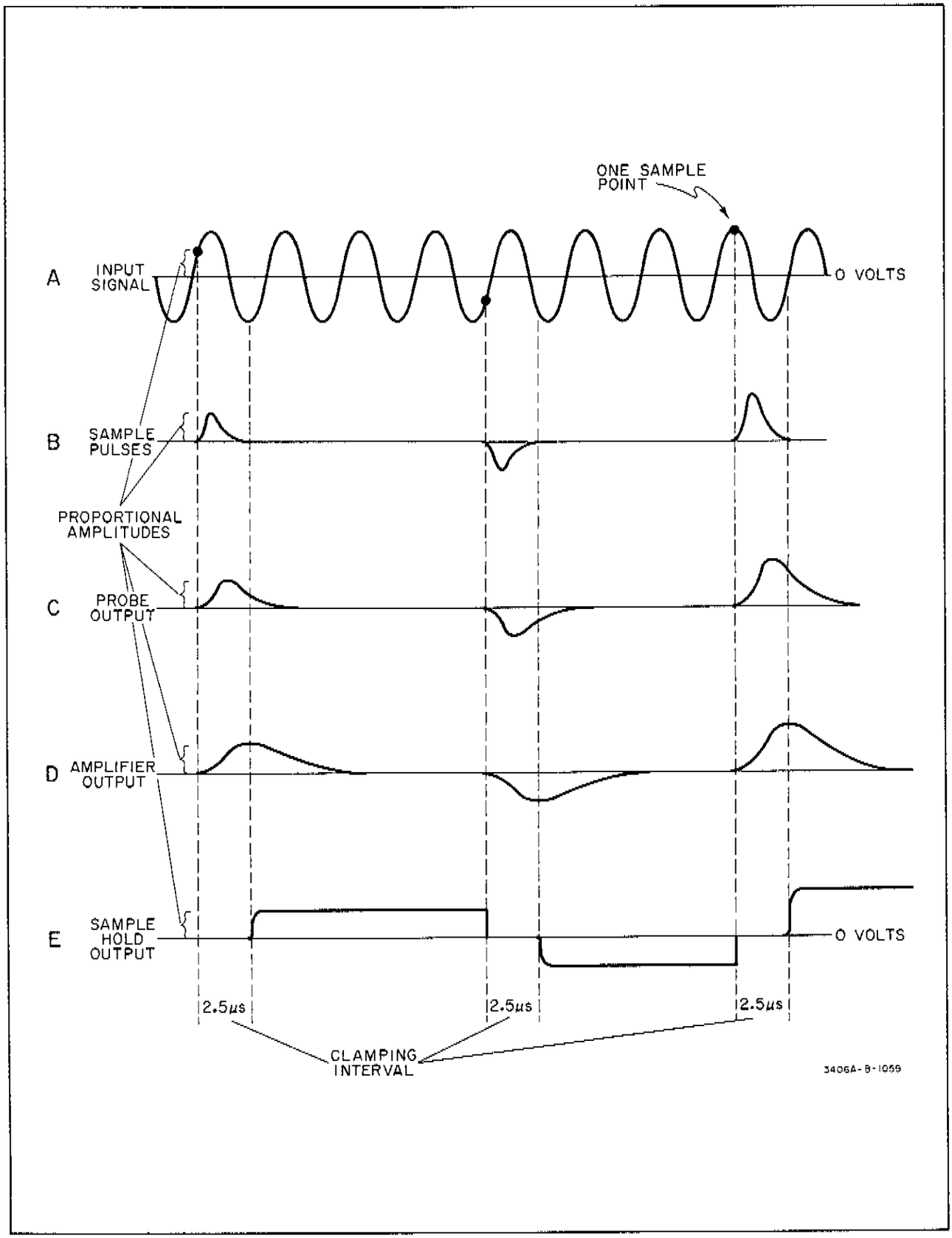


Figure 4-5. Sample Hold Output

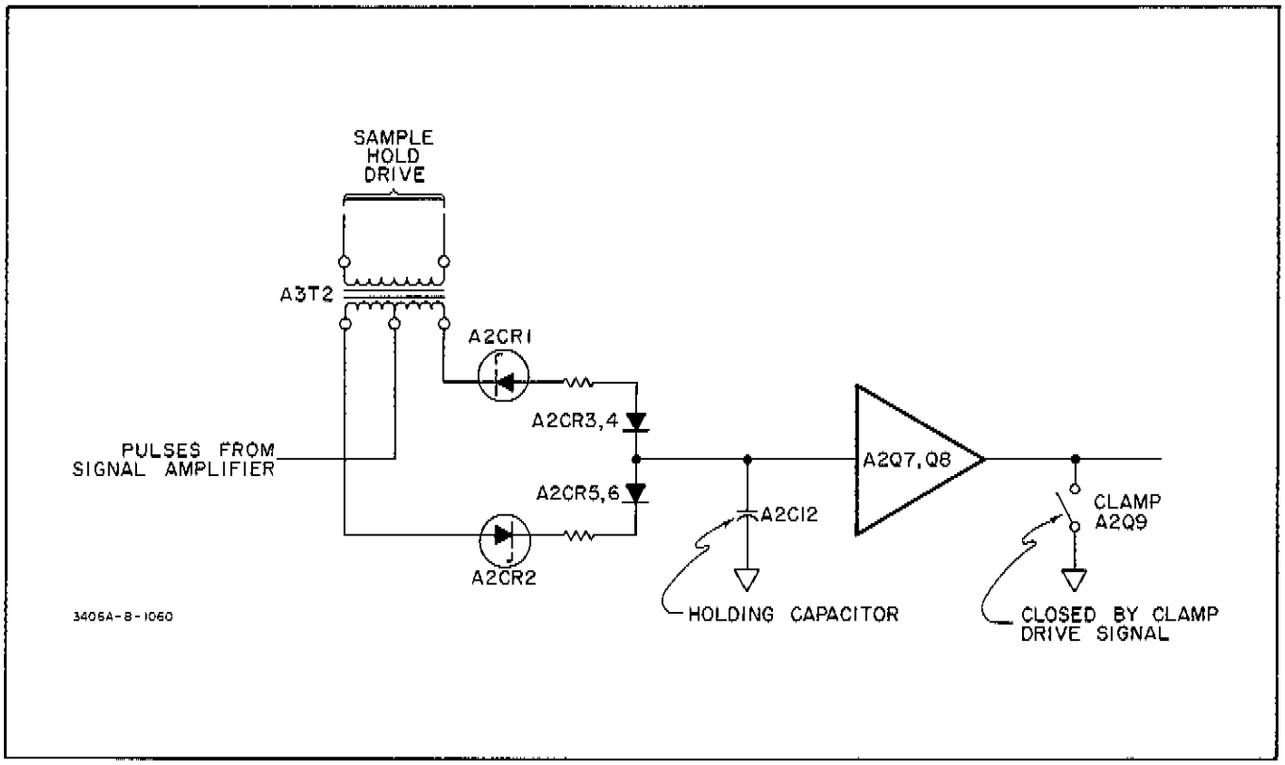


Figure 4-6. Sample Hold Circuit

4-32. The end result of the Sample Hold Circuit is a series of square wave like pulses with amplitudes proportional to the peak amplitudes of each pulse from the Signal Amplifier, as illustrated in Figure 4-5. Note, that after a sufficient number of pulses (samples) from the Signal Amplifier, the Sample Hold Output becomes statistically equivalent to the input signal. This statistically equivalent signal is applied to the Detector Circuit and the SAMPLE HOLD OUTPUT jack on the rear panel. Refer to Section III for applications using this statistically equivalent signal available at the SAMPLE HOLD OUTPUT jack.

4-33. The Detector Circuit (p/o A2) detects the absolute average value of all the pulses from the Sample Hold Circuit. The Detector Circuit has an input-output linearity characteristic that eliminates the low level non-linear region of common rectifying type detectors. The dc output of the Detector Circuit is applied to the Non-Linear Meter Circuit (p/o A2).

4-34. Because the signal-to-noise ratio is small on the lower ranges, the noise caused by the sampling probe starts affecting the apparent gain of the detector as shown in Figure 4-7. The gain of the detector is low for small signal-to-noise ratios and approaches unity gain with larger signal-to-noise ratios. To compensate for this non-linear gain caused by the signal-to-noise ratio, a Non-Linear Meter Circuit is inserted between the detector and the final Meter Amplifier. The gain of the Non-Linear Meter Circuit is the inverse of the detector gain as shown in Figure 4-7. Therefore, the resulting gain of both circuits is unity and the effects of small signal-to-noise ratios are eliminated.

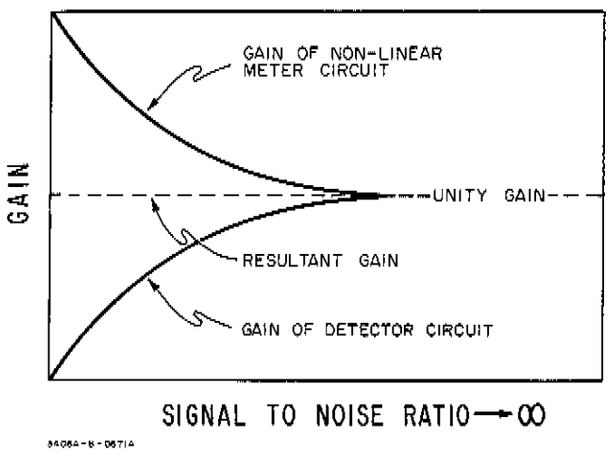


Figure 4-7. Resultant Gain

4-35. The gain of the Non-Linear Meter Circuit is controlled by negative feedback around a differential amplifier as shown in Functional Block Diagram, Figure 7-1. The amount of feedback is controlled by the front panel RANGE pushbuttons and internal "tracking" adjustments.

4-36. The output of the Non-Linear Meter Circuit is applied to the Damping/Hold Circuit. The Damping/Hold Circuit (p/o A3) impresses heavy damping on the meter movement for small changes appearing in the input voltage being measured. For large changed in input voltage, the Damping/Hold Circuit results in fast

meter movements. This type of damping is used to reduce meter jitter (small meter movements) caused by the finite sampling rate of the voltmeter as described in Paragraph 4-11. The Damping/Hold Circuit also performs the meter hold operation when the push-button on the case of the probe is depressed.

4-37. The output of the Damping/Hold Circuit is applied to the meter, M1, for meter indication in rms, and the RECORDER OUTPUT jack on the rear panel. The RECORDER OUTPUT is used for monitoring the input signal on a dc recorder or digital voltmeter.

4-38. The Stabilizing (Stab.)Amplifier (p/o A2) and Low Pass Filter connected in the feedback path from the Sample Hold Circuit passes only low frequencies around 10 Hz and any dc drift. The Stabilizing Amplifier amplifies any dc drift and any 10 Hz component caused by the sampling frequency sweeping between 10 kHz and 20 kHz at a 10 Hz rate. The output of the Stabilizing Amplifier is applied to the Sampling Probe Assembly to stabilize the Signal Amplifier and eliminate any dc from getting into the Sample Hold Circuit.

NOTE

A Functional Block Diagram of the 3406A Voltmeter is shown in Figure 7-1. Pertinent notes and waveforms are given on this Functional Block Diagram to aid in understanding the theory of operation.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains instructions and information necessary for the maintenance of the -hp- Model 3406A Broadband Sampling Voltmeter. Included are In-Cabinet Performance Checks, Adjustment and Calibration Procedures, Servicing Tips, and Troubleshooting Procedures.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to perform the operations outlined in this section is listed in Table 5-1. This table includes the type of instrument required, critical specifications, use and recommended model, if the model recommended is not available, equipment which meets or exceeds the required characteristics listed may be substituted.

5-5. IN-CABINET PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front panel procedures designed to compare the Model 3406A voltmeter with its published specifications (Table 1-1). These tests may be incorporated in periodic maintenance, post repair, and incoming quality control inspection. The In-Cabinet Performance Checks should be conducted before any attempt is made to adjust or calibrate the instrument internally. During the In-Cabinet Performance Checks, connect the Model 3406A Voltmeter to the ac source through a variable power-line transformer so that line voltage may be varied ±10% from 115 or 230 vac to assure that the instrument operates correctly at various ac line voltages.

NOTE

Before starting the In-Cabinet Performance Checks allow a 30-minute warmup and stabilization period. ZERO and CALIBRATE the 3406A with the bare probe inserted into 1 VOLT receptacle on the front panel as outlined in Paragraph 3-8 and 3-9. To assure elimination of RF interference and proper operating temperature both the side and top covers must be on during all In-Cabinet Performance Checks.

5-7. If the Model 3406A does not meet the specification test limits given in the following procedures, perform the Adjustment and Calibration Procedures outlined in Paragraph 5-16.

5-8. ACCURACY AND RANGE-TO-RANGE TRACKING (UP TO 10 MHZ).

CAUTION

DO NOT ALLOW DC STANDARD OR OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

a. The accuracy and range-to-range tracking test setup is illustrated in Figure 5-1.

The following equipment is required for the check:

Oscillator, (-hp- Model 652A)
DC Standard, (-hp- Model 741A)
AC Voltmeter, (-hp- Model 400E/EL)
DC Null Voltmeter, (-hp- Model 419A)
Thermal Converter, (-hp- Model 11050A)
Bucking Supply, (see Table 5-1)

b. Connect the Model 3406A as illustrated in Figure 5-1, and depress 1 volt RANGE pushbutton.

NOTE

The ambient temperature of the 50 ohm tee should be approximately equal to that of bare probe.

c. Connect dual banana plug to dc standard output, and adjust dc standard output for 1.000 volts.

d. Adjust bucking supply for null indication on null voltmeter.

e. Move dual banana plug connection to oscillator output, and set oscillator output frequency to 25 kHz.

f. Adjust oscillator output amplitude for null indication on null voltmeter.

g. Observe Model 3406A meter indication between 0.95 and 1.05 volts. This verifies 3406A accuracy of ±5% at 25 kHz.

h. The ac voltmeter connected to SAMPLE HOLD OUTPUT should read between 0.301 and 0.331 volts. This verifies SAMPLE HOLD OUTPUT accuracy to be the same as the full scale accuracy of the instrument.

i. Repeat steps a through f for oscillator out-

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Oscillator	Frequency Range: 10 KHz to 10 MHz	Performance Checks Calibration	-hp- Model 652A Test Oscillator
VHF Oscillator	Output Frequency: 10 MHz to 400 MHz Output Level: 0 dBm into 50Ω load	Performance Checks	-hp- Model 608C VHF Signal Generator
UHF Oscillator	Output Frequency: 500 MHz to 1 GHz	Performance Checks	-hp- Model 612A UHF Signal Generator
AC Voltmeter	Frequency Range: 1 KHz to 100 KHz Voltage Range: -25 mV to 1 V Accuracy: ±1%	Performance Checks Calibration Troubleshooting	-hp- Model 400E AC Voltmeter
DC Null Voltmeter	Voltage Range: ±10 mV Accuracy: ±2%	Performance Checks Calibration	-hp- Model 419A DC Null Voltmeter
DC Voltmeter	Voltage Range: 0 to 20 volts Accuracy: ±1%	Calibration Troubleshooting	-hp- Model 414A Auto Voltmeter
DC Standard	Output Voltage: 1 V at 200 mA Accuracy: 0.1%	Performance Checks Calibration	-hp- Model 741A AC-DC Differential Voltmeter DC Standard
Power Meter	Frequency Range: 500 MHz to 1 GHz Power Range: -10 dBm Accuracy: 0.5%	Performance Checks	431B/478A Power Meter/ Thermistor Mount and 8402A Calibrator
Thermal Converter	Frequency Range: 10 KHz to 10 MHz	Performance Checks	-hp- Model 11050A
Micro-potentiometer	Frequency Range: 10 MHz to 500 MHz Output Voltage: 0.3 V rms Accuracy: NBS calibrated	Performance Checks	Ballantine Model 440 Micropotentiometer
Bucking Supply	BT1: 1.34 V battery, mercury R1: 50Ω variable ±10% R2: 100Ω variable ±10% 20-turn R3: 6500Ω ±1%	Performance Checks Calibration	Mallory RM-42R -hp- Part No. 2100-0002 -hp- Part No. 2100-0973 -hp- Part No. 0811-0392
Slide Screw Tuner	Frequency Range: 500 MHz to 1 GHz Impedance: 50Ω	Performance Checks	-hp- Model 872A Coaxial Slide Screw Tuner
Slotted Line	Frequency Range: 500 MHz to 1 GHz Residual SWR: less than 1.04	Performance Checks	-hp- Model 805C Slotted Line
Standing Wave Indicator	Frequency: 1000 Hz ±2% Range: 70 dB	Performance Checks	-hp- Model 415D Standing Wave Indicator
Oscilloscope	Frequency Range: 50 MHz Vertical Sensitivity: 005 V/cm	Calibration Troubleshooting	-hp- Model 140A/1402A Oscilloscope
Low-Pass Filter	Cutoff Frequency: -1200 MHz	Performance Checks	-hp- Model 360B Low-Pass Filter
Attenuator	Attenuation: 10 dB Frequency Range: 500 MHz to 1 GHz Output Impedance: 50Ω	Performance Checks	Weinschel Engineering Model 50-10
3406A Accessory Kit	----	Performance Checks Calibration	-hp- Model 11064A
Resistor	44.2K ±1% 1/2 W	Performance Checks	-hp- Part No. 0698-4936
Variable Line Transformer	Voltage Range: 103 to 127 V, 207 to 253V Power Capability: 17 watts	Performance Checks	Superior Type VC1M

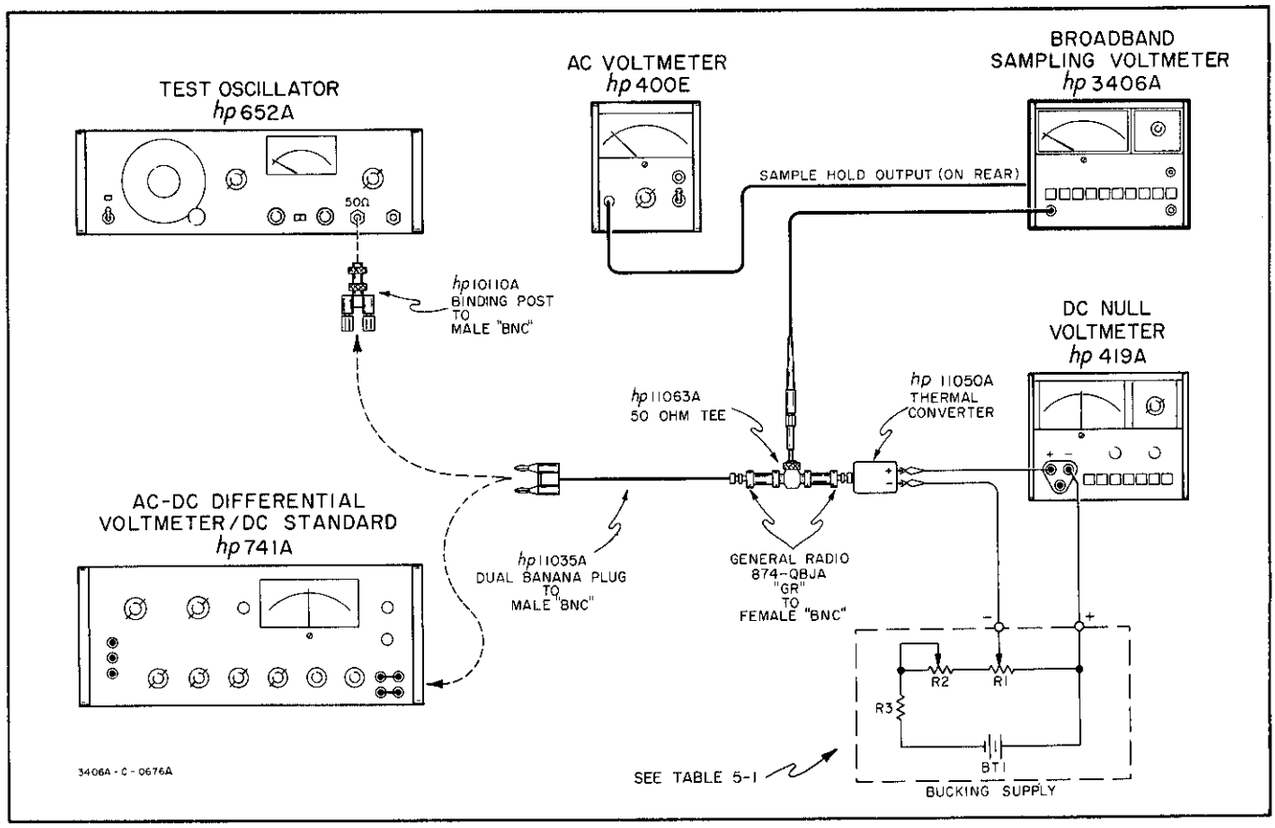


Figure 5-1. Accuracy and Range-to-Range Tracking Test Setup

put frequencies of 100 kHz, 1 MHz, and 10 MHz, and observe Model 3406A meter indication between 0.97 and 1.03 volts at each frequency. This verifies 3406A accuracy of ±3% at above frequencies.

j. With oscillator frequency at 10 MHz, adjust the REF SET control on oscillator for a reference indication on oscillator meter; do not adjust the amplitude control to set the reference.

k. Disconnect the thermal converter, and terminate the 11063A tee with a 50 ohm load (Part of Accessory Kit).

l. Using oscillator attenuator, increase output by 10 dB (+20 dB).

m. Model 3406A should indicate between 3.07 and 3.25 volts on 3 volt range.

n. Using oscillator attenuator, decrease output in 10 dB steps, and select 3406A RANGE for full scale and third scale indications; the 3406A indication should be within ±3% of full scale at full scale and third scale. (.316 on 0 to 1 scale.

NOTE

If the Model 3406A does not track properly, for example, within specifications at full scale but reads high or low at third scale perform the tracking adjustment outlined in Paragraph 5-36.

o. Continue the Range-to-Range tracking check (steps 1, m and n) at 1 MHz, 100 kHz and 25 kHz. Adjust the oscillator amplitude to the reference setup in step j each time the frequency is changed. (3406A accuracy is ±5% at 25 kHz).

5-9. 10 MHz TO 500 MHz FREQUENCY RESPONSE CHECK.

5-10. The 10 MHz to 500 MHz frequency response test setup is illustrated in Figure 5-2. The following equipment is required for this check:

VHF Signal Generator, (-hp- Model 608C)
UHF Signal Generator, (-hp- Model 612A)
Micropotentiometer, (Ballantine Model 440)
DC Null Voltmeter, (-hp- Model 419A)
Bucking Supply, (see Table 5-1)

a. Connect Model 3406A as illustrated in Figure 5-2.

NOTE

The micropotentiometer must have the proper radial resistance and current rating to deliver 0.3 volts at its output.

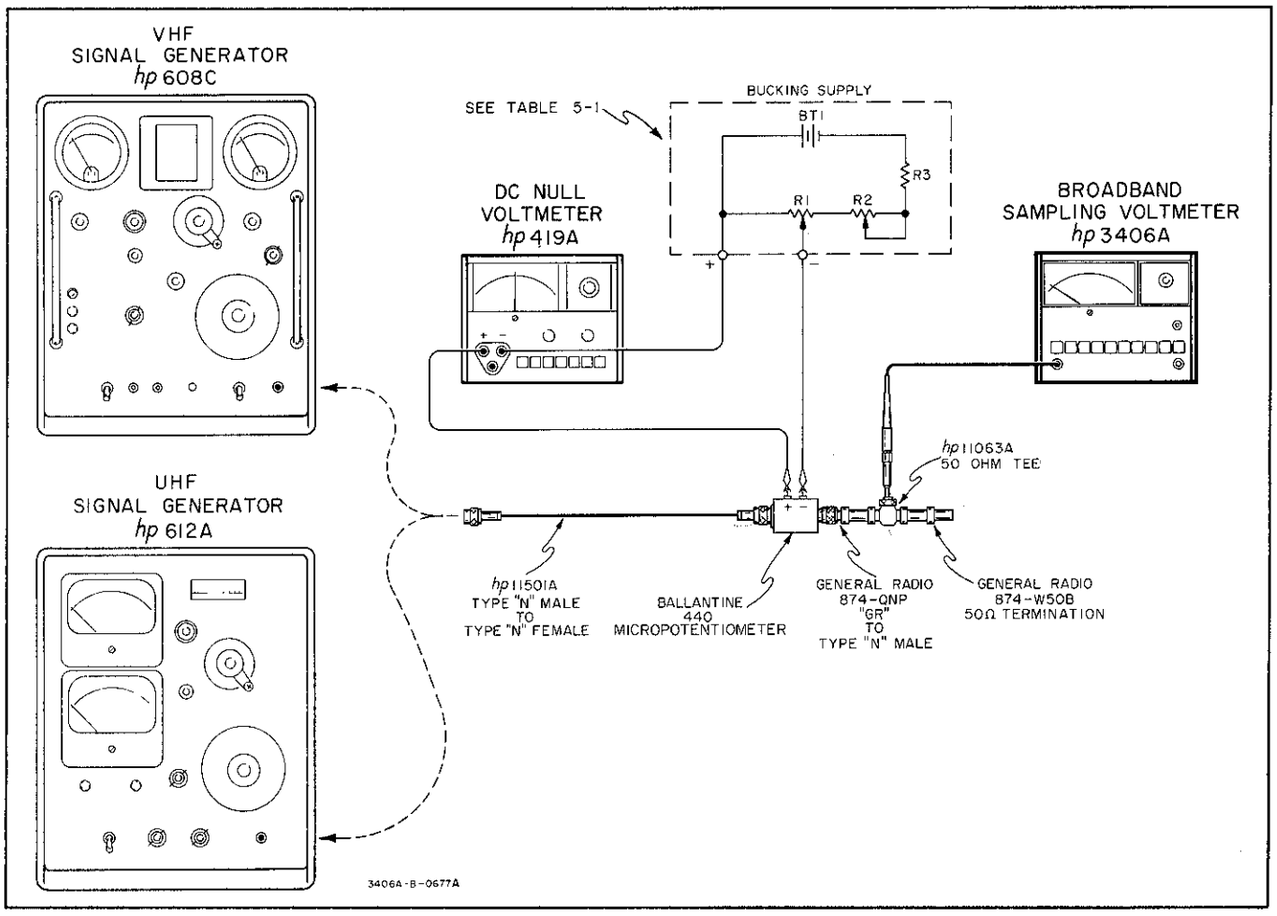


Figure 5-2. 10 MHz to 500 MHz Frequency Response Test Setup

b. Connect micropotentiometer to VHF oscillator. Set oscillator output frequency to 10 MHz and adjust output voltage level for a reading of 0.3 volts on 3406A .3 volt RANGE.

c. Adjust bucking supply for a null indication on null voltmeter.

NOTE

The micropotentiometer and its dc output monitoring circuit is now referenced to the absolute voltage measurement made in Paragraph 5-8.

d. Set VHF oscillator output frequency to 50 MHz and 100 MHz each time readjusting only the oscillator output level to maintain null indication on null voltmeter.

e. Observe Model 3406A meter indication between 0.291 and 0.309 volts at both 50 MHz and 100 MHz. This verifies 3406A accuracy of ±3% at 50 MHz and 100 MHz.

f. Set VHF oscillator output frequency to 200 MHz, 300 MHz, and 400 MHz and readjust oscillator output level to maintain null indication on null voltmeter. The 3406A should indicate between 0.285 and 0.315 volts. This verifies 3406A accuracy of ±5%.

g. Replace VHF oscillator with UHF oscillator. Set UHF oscillator frequency to 500 MHz and adjust output level for null indication on null voltmeter.

h. Observe Model 3406A meter indication between 0.285 and 0.315 volts. This verifies 3406A accuracy of ±5% at 500 MHz.

NOTE

If the Model 3406A did not meet any of the above specification limits perform the adjustment and calibration outlined in Paragraph 5-16.

5-11. 500 MHz TO 1 GHz FREQUENCY RESPONSE CHECK.

5-12. The 500 MHz to 1 GHz frequency response test setup is illustrated in Figure 5-3. The following equipment is required for this check:

Coaxial Slide Screw Tuner, (-hp- Model 872)
Low Pass Filter, (-hp- Model 360B)

Power Meter, (-hp- Model 431B/478A)
50Ω Terminations, (-hp- Model 908A)
UHF Oscillator, (-hp- Model 612A)
10 dB Attenuator, (Weinschel Model 50-10)
Slotted Line, (-hp- Model 805C)
Standing Wave Indicator, (-hp- Model 415D)

NOTE

In this check, the power meter must be used in conjunction with a power meter calibrator (-hp- Model 8402A) and differential voltmeter (-hp- Model 741A) to have the required accuracy. Refer to the Operating and Service Manual of the power meter calibrator for proper setup and use of the dc substitution procedure to obtain 0.5% accuracy for the power meter.

a. Connect Model 3406A as illustrated in Figure 5-3.

NOTE

A slotted line (-hp- Model 805C) and a standing wave indicator (-hp- Model 415D) must be used to adjust the slide screw tuner in both channels of the test setup for a minimum standing-wave ratio. Refer to the slide screw tuner Operating Note for proper setup. Also, the approximate insertion loss of the slide screw tuner should be taken into account.

b. Connect UHF oscillator to Model 3406A channel, and set output frequency to 500 MHz.

c. Adjust slide screw tuner for minimum standing-wave ratio, and record the setting of the slide screw tuner.

d. Connect UHF oscillator to power meter channel, and adjust slide screw tuner for minimum standing-wave ratio.

e. Adjust output of UHF oscillator for a -10 dB indication on power meter. Monitor the -10 dB indication for a few minutes to assure that the UHF oscillator has stabilized.

f. Reconnect the UHF oscillator to 3406A channel as illustrated in Figure 5-3, and readjust the slide screw tuner to setting recorded in step c.

g. Observe Model 3406A indication of -10 dB ±5% full scale (0.65 to 0.75 on 0 to 1 scale).

h. Repeat steps b thru g for UHF oscillator frequencies of 600 MHz and 700 MHz.

i. Repeat steps b thru g for UHF oscillator frequencies of 800 MHz, 900 MHz, and 1 GHz. 3406A should indicate -10 dB ±8% full scale (0.62 to 0.78 on 0 to 1 scale).

NOTE

If the Model 3406A did not meet any of the above specification limits perform the adjustment and calibration outlined in Paragraph 5-16.

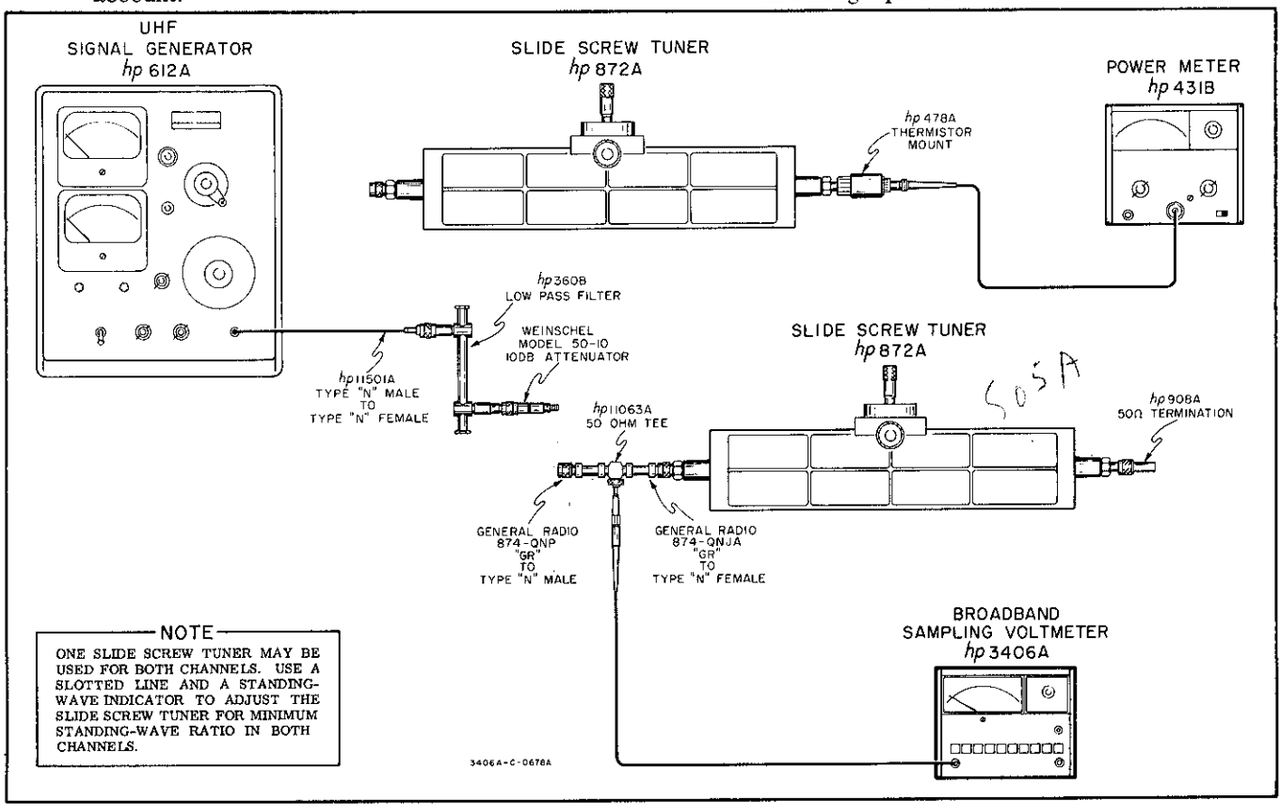


Figure 5-3. 500 MHz to 1 GHz Frequency Response Test Setup

5-13. INPUT IMPEDANCE CHECK.

a. A test oscillator (-hp- Model 652A) and 44.2K ohm resistor (-hp- Part No. 0698-4936) are required for this check.

b. With 11072A Isolator attached to probe, connect the Model 3406A to 50Ω output on oscillator through the resistor as illustrated in Figure 5-4.

c. Depress Model 3406A 1 volt RANGE pushbutton. Set oscillator to 10 kHz, and adjust output for full scale deflection on 3406A meter.

d. Increase frequency of oscillator until Model 3406A indicates .707 volts. Oscillator frequency should be above 200 kHz.

NOTE

Oscillator frequency of 200 kHz indicates total input capacitance of 10 pF. Oscillator frequency of 250 kHz indicates total input capacitance of 8 pF.

e. This verifies input resistance of 100K ohms with total shunt capacitance of < 10 pF with the Isolator Tip attached to probe. Section III shows typical input impedance with the Isolator Tip for frequencies above 1 MHz. For relative measurements with the same source resistance the bare probe may be used to achieve higher input impedance.

5-14. METER RESPONSE TIME CHECK.

a. Depress 3406A 1 volt RANGE pushbutton and insert probe into 1 VOLT receptacle.

b. Depress 3406A CAL pushbutton and adjust CALIBRATE control for 1 volt indication on meter.

c. Depress 3 volt RANGE pushbutton and allow few seconds for meter to stabilize.

d. Depress 1 volt RANGE pushbutton and verify meter indicates 1 volt ±3% (between 0.97 and 1.03) within 3 seconds.

e. If the 3406A did not respond within 3 sec perform the meter response adjustment outlined in Paragraph 5-26.

NOTE

In the above procedures a meter jitter of ±1% of reading may be observed. This jitter (small movements of the meter needle over a period of time) is within the specification of the Model 3406A and is caused by the sampling technique used within the 3406A. Refer to Section IV for additional information.

5-15. PUSH-TO-HOLD CHECK.

a. Repeat steps a and b given in Paragraph 5-14.

b. Push the meter-hold pushbutton and then remove the probe from the 1 VOLT receptacle.

c. Meter should retain 1 volt indication for at least 15 seconds.

5-16. ADJUSTMENT AND CALIBRATION PROCEDURES.

The following paragraphs contain a complete adjustment and calibration procedure for the Model 3406A. This procedure should be conducted only after it has been established that the Model 3406A does not meet its published specifications. Indiscriminate adjustment of internal controls to refine readings may actually cause more difficulty. Two external adjustments, ZERO and CALIBRATE are outlined in Paragraphs 3-8 and 3-9 and should be performed prior to making any measurements or when changing the probe tip.

5-17. PREPARATION FOR CALIBRATION (COVER REMOVAL).

5-18. The 3406A is housed in a box within a box construction to eliminate RF interference. Perform

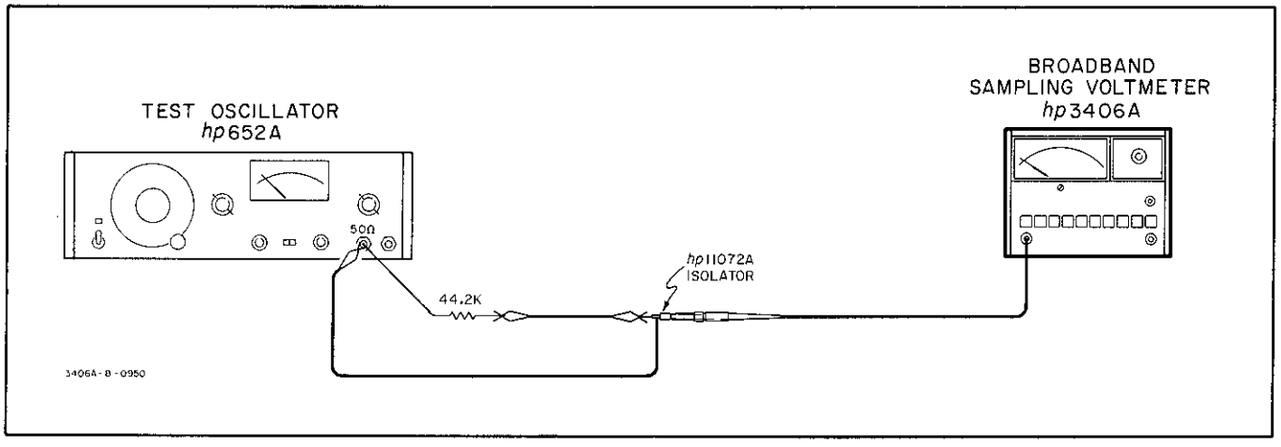


Figure 5-4. Input Impedance Test Setup

the steps outlined in Figure 5-5 to prepare the instrument for adjustment and calibration.

NOTE

All adjustments are available through the top shield or side gussets as illustrated in Figure 5-6. The circled numbers indicate the alignment sequence (1)→(21). Figure 5-6 also gives the reference designator for each adjustment.

Perform steps (3) thru (5) in Figure 5-5 only if it is necessary to make the components or test points on the top or bottom assemblies accessible.

5-19. MECHANICAL METER ZERO.

a. Turn the instrument on and let it warm up for at least 20 minutes. Turn the instrument off after warmup and allow at least one minute for all capacitors to discharge.

b. Rotate the mechanical zero adjustment screw (Figure 3-1) clockwise until the meter pointer is to the left of zero and begins moving upscale toward zero; stop when the meter pointer is right on zero. If the pointer overshoots, continue turning clockwise and repeat the procedure in this step.

c. After aligning the meter pointer on zero, rotate the zero adjustment screw slightly counterclockwise to free the adjustment screw from the meter suspension. If the meter pointer moves during this step, repeat steps b and c.

5-20. POWER SUPPLY ADJUSTMENT. (1)

5-21. A dc Voltmeter (-hp- Model 741A or 414A) is required for this adjustment.

a. Remove top shield; connect voltmeter between +15 V and ground test points on Top Assembly A2. (See Figure 7-5 for Test Point location).

b. Adjust (1) -15 V ADJ (A3R67) for +15 volt (±.2 volts) indication on dc voltmeter.

c. Connect voltmeter between -15 V and ground test points on Top Assembly A2.

d. DC voltmeter should indicate between -14.6 and -15.4 volts.

NOTE

If the power supply is not within the test limits given above perform the regulation and ripple checks outlined in Paragraph 5-57 and 5-58.

5-22. PROBE BALANCE ADJUSTMENT (2), (3) AND (7).

5-23. A high frequency oscilloscope (-hp- Model 140A/1402A is required for this adjustment.

a. Connect 3406A to oscilloscope using probe-to-BNC Adapter (-hp- Model 10218A), part of 11064A Accessory Probe Kit.

b. Set oscilloscope to most sensitive vertical gain and sweep to .1 ms/cm.

c. Depress Model 3406A 3 volt RANGE Pushbutton and adjust (2) SAMPLE HOLD BIAS (A2R19) for null on oscilloscope (minimum amplitude of pulses).

d. Depress .001 volt RANGE pushbutton and adjust (7) BRIDGE BAL (A3R72) for minimum noise on oscilloscope.

NOTE

Interaction exists between adjustments (2) and (7); therefore repeat steps c and d for optimum noise on both ranges. The probe output noise must be less than 30 mV peak-to-peak.

e. Insert 3406A probe in 1 VOLT receptacle on front panel; release CAL pushbutton; set 3406A to .3 volt RANGE.

f. Connect oscilloscope to SAMPLE HOLD OUTPUT on 3406A rear panel; set oscilloscope vertical sensitivity to 0.2 V/cm and sweep to 1 ms/cm.

g. Adjust (3) SAMPLE HOLD ZERO (A2R39) for minimum amplitude pulses on oscilloscope.

5-24. METER AMPLIFIER ZERO ADJUSTMENT. (4)

5-25. No external test equipment is required for the meter amplifier zero adjustment.

a. Remove top shield; the front, center screw on Top Assembly and lift the hinged chassis up.

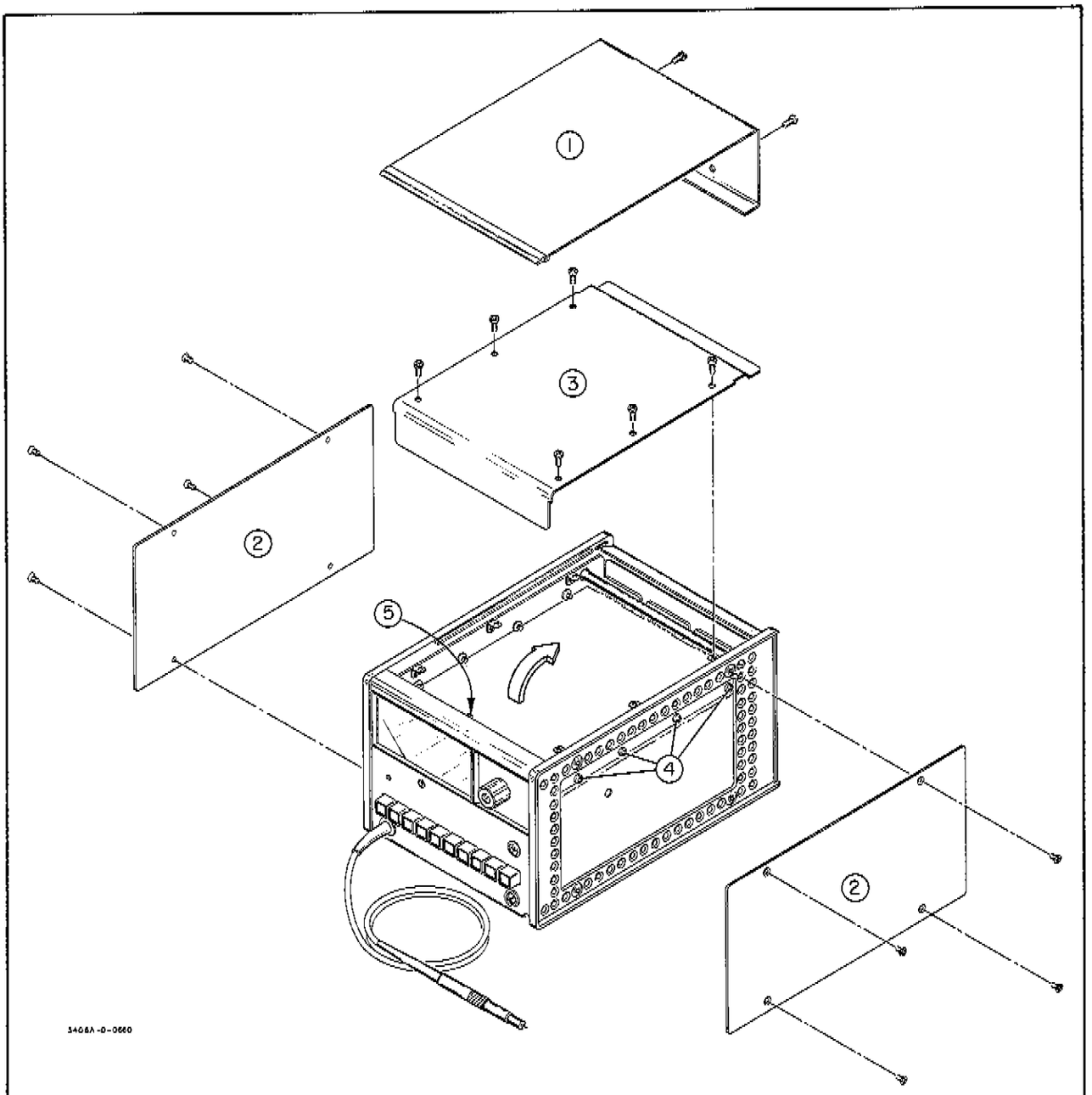
b. Short TP2 to the ground test point located on the Bottom Assembly A3. (See Page 7-12 for test point location).

c. Adjust (4) METER ZERO (A3R16) for a zero reading on 3406A meter.

d. Remove short; replace center screw and shield.

5-26. METER AMPLIFIER RESPONSE ADJUSTMENT (5).

5-27. No external test equipment is required for the meter amplifier response adjustment.



(1) Remove top cover.

(2) Remove both right and left side covers.

NOTE

The instrument is now ready for calibration and adjustment.

(3) Remove the "top shield" to make the + and - 15 v test points and Top Assembly accessible.

(4) Remove the four screws from both the right and left side gussets.

(5) Remove the front-center screw on Top Assembly.

NOTE

The "hinged chassis" may now be lifted up to make the Bottom Assembly accessible.

Figure 5-5. Preparation for Calibration or Repair

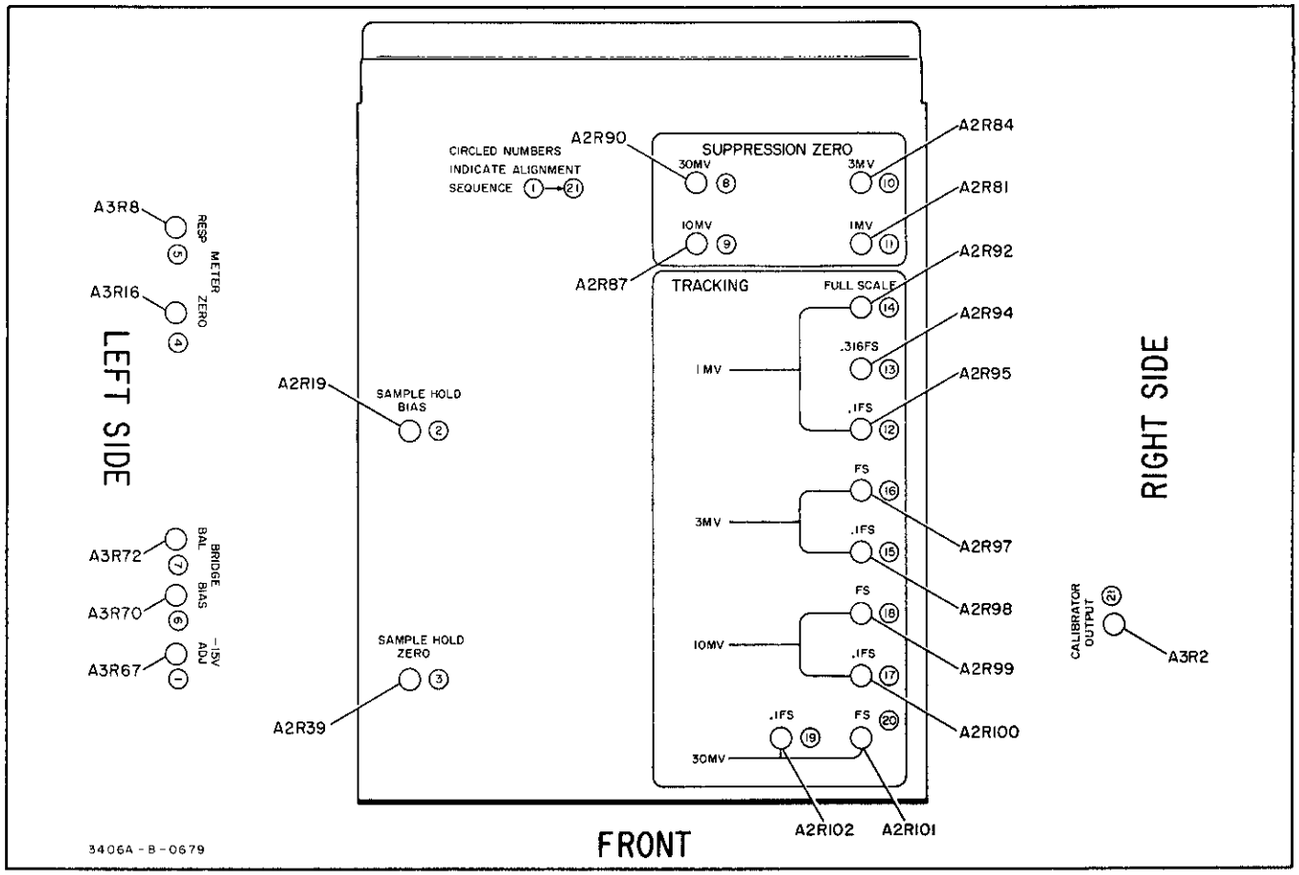


Figure 5-6. Adjust Point Location

a. Insert 3406A probe in 1 VOLT receptacle; depress CAL and 1 volt RANGE pushbuttons.

b. Adjust front panel ZERO control for 3406A meter deflection of 0.8 (reference point).

c. Release CAL pushbutton; allow 1 minute for the 3406A to stabilize.

NOTE

Meter response is properly adjusted when the meter needle moves rapidly to a point just below the reference point and then moves directly to the reference point in a few small and fast incremental steps. Misadjustment is indicated by overshoot or undershoot and many incremental steps.

d. Depress CAL pushbutton; note response of meter. If misadjustment of the response is indicated, proceed with the following steps.

e. Release CAL pushbutton; allow 1 minute for the 3406A to stabilize.

f. Rotate (5) METER RESP (A3R8) a small amount in a CW direction.

g. Depress CAL pushbutton; note response of meter. If response improved from step d, repeat steps e and f. If response is worse than the response in step d, repeat steps e and f, rotating (5) METER RESP in a CCW direction.

5-28. FREQUENCY RESPONSE ADJUSTMENT. (6)

5-29. The test setup illustrated in Figure 5-3 is required for the frequency response adjustment. The following equipment is required for this adjustment:

Coaxial Slide Screw Tuner, (-hp- Model 872A)
Low Pass Filter, (-hp- Model 360B).
Power Meter, (-hp- Model 431B/478A)
50Ω Terminations, (-hp- Model 908A)
UHF Oscillator, (-hp- Model 612A)
10 dB Attenuator, (Weinschel Model 50-10)
Slotted Line, (-hp- Model 805C)
Standing Wave Indicator, (-hp- Model 415D)

NOTE

In this procedure, the power meter must be used in conjunction with a power meter calibrator (-hp- Model 8402A) and a differential voltmeter (-hp- Model 741A) to have the required accuracy. Refer to the Operating and

Service Manual of the power meter calibrator for proper setup and use of the dc substitution procedure to obtain 0.5% accuracy for the power meter.

a. Connect test setup illustrated in Figure 5-3.

NOTE

A slotted line (-hp- Model 805C) and a standing wave indicator (-hp- Model 415B) must be used to adjust the slide screw tuner in both channels of the test setup for a minimum standing ratio. Refer to the slide screw tuner Operating Note for proper setup. Also, the approximate insertion loss of the slide screw tuner should be taken into account.

b. Connect UHF oscillator to Model 3406A channel, and set output frequency to 1 GHz.

c. Adjust slide screw tuner for minimum standing-wave ratio, and record the setting of the slide screw tuner.

d. Connect UHF oscillator to power meter channel, and adjust slide screw tuner for minimum standing-wave ratio.

e. Adjust output of UHF oscillator for a -10 dB indication on power meter. Monitor the -10 dB indication for a few minutes to assure that the UHF oscillator has stabilized.

f. Reconnect the UHF oscillator to 3406A channel; and readjust the slide screw tuner to setting recorded in step c.

g. Set 3406A to .3 volt RANGE, and note indication on meter.

e. Repeat steps b thru f for UHF oscillator frequency of 500 MHz.

f. Adjust (6) BRIDGE BIAS (A3R70) for same reading obtained in step g plus 0.5%.

NOTE

Setting BRIDGE BIAS 0.5% high at 500 MHz ensures a more ideal response over the entire 3406A frequency range.

g. Repeat steps b thru f for UHF oscillator frequency of 1 GHz.

h. If 3406A reading is not within 1% of reading noted in step g, repeat steps e and f.

5-30. SIGNAL AMPLIFIER GAIN ADJUSTMENT. (FRONT PANEL).

NOTE

This adjustment sets the Signal Amplifier gain, and verifies proper operation of the Sampling Probe Assembly A1, Pulse Generator p/o A3, Signal Amplifier p/o A2, and Sample Hold Circuit p/o A2. The SAMPLE HOLD OUTPUT is used because of its location in the circuit.

5-31. The test setup illustrated in Figure 5-1 is used for the signal amplifier gain adjustment. The following test equipment is required:

DC Standard, (-hp- Model 741A)
Oscillator, (-hp- Model 652A)
1 Volt Thermal Converter, (-hp- Model 11050A)
Null Voltmeter, (-hp- Model 419A)
Bucking Supply, (see Table 5-1)
AC Voltmeter, (-hp- Model 400E)
Connecting Hardware shown in Figure 5-1.

a. Construct test setup illustrated in Figure 5-1.

CAUTION

DO NOT ALLOW DC STANDARD OR OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

b. Connect dual banana plug to dc standard output; set dc standard output to 1 volt; adjust bucking supply for null (zero) indication on null voltmeter.

c. Move dual banana plug to oscillator output; set oscillator output frequency to 1 MHz output amplitude for null indication on null voltmeter.

d. Adjust CALIBRATE on 3406A front panel for a SAMPLE HOLD OUTPUT of 0.316 volts on ac voltmeter.

NOTE

This procedure establishes the 1 volt reference used to set the calibrator (1 VOLT receptacle) output voltage in paragraph 5-38.

5-32. BRIDGE BALANCE ADJUSTMENT. (7)

5-33. Because of interaction existing between adjustment (2) and (7), the BRIDGE BAL (7) was set in Paragraph 5-22. No additional adjustment is required.

5-34. METER SUPPRESSION ZERO ADJUSTMENTS. (8) – (11)

5-35. To properly ground the probe for this adjustment, the 11063A Tee with 50Ω termination is used.

a. Center the front panel ZERO control, and insert the 3406A probe into terminated 50Ω tee with no source connected.

b. Depress 3406A 0.03 volt RANGE pushbutton and adjust (8) 30 MV (A2R90) for zero indication on 3406A meter.

c. Depress 0.01 volt RANGE pushbutton and adjust (9) 10 MV (A2R87) for zero indication on 3406A meter.

d. Depress 0.003 volt RANGE pushbutton and adjust 3 MV (A2R84) for zero indication on 3406A meter.

e. Depress 0.001 volt RANGE pushbutton and adjust (11) 1 MV (A2R81) for zero indication on 3406A meter.

5-36. NON-LINEAR METER AMPLIFIER ADJUSTMENT. (Tracking). (12) – (20)

5-37. An oscillator (-hp- Model 651A or 652B) and an ac voltmeter (-hp- Model 400E) are required for this adjustment.

a. Using the front panel ZERO control, zero the voltmeter on the .001, .003, .01, .03 and .1 volt RANGE with the bare probe inserted into terminated 50Ω tee with no source.

b. Connect test setup illustrated in Figure 5-7; set oscillator output frequency to 1 MHz; and output voltage for 100 MV indication on ac voltmeter.

c. Using oscillator attenuator reduce output 60 dB; and depress 3406A .001 volt RANGE pushbutton.

d. Adjust (12) .1 FS (A2R95) for 3406A meter indication of 0.1 on 0 to 1 scale.

e. Using oscillator attenuator increase output 10 dB; adjust (13) .316 FS (A2R94) for 3406A meter indication of 1 on 0 to 3 scale (which is 0.316 of FS on 0 to 1 scale).

f. Using oscillator attenuator increase output 10 dB; adjust (14) FULL SCALE (A2R92) for 3406A meter indication of 1 on 0 to 1 scale.

g. Depress 3406A .003 volt RANGE pushbutton.

h. Using oscillator attenuator reduce output 10 dB; adjust (15) .1 FS (A2R98) for 3406A meter indication of 0.1 on 0 to 1 scale.

i. Using oscillator attenuator increase output 20 dB; adjust (16) FS (A2R97) for 3406A meter indication of 1 on 0 to 1 scale.

j. Depress 3406A .01 volt RANGE pushbutton.

k. Using oscillator attenuator reduce output 10 dB; adjust (17) .1 FS (A2R100) for 3406A meter indication of 0.1 on 0 to 1 scale.

m. Using oscillator attenuator increase output 20 dB; adjust (18) FS (A2R99) for 3406A meter indication of 1 on 0 to 1 scale.

n. Depress 3406A .03 volt RANGE pushbutton.

o. Using oscillator attenuator reduce output 10 dB; adjust (19) .1 FS (A2R102) for 3406A meter indication of 0.1 on 0 to 1 scale.

p. Using oscillator attenuator increase output 20 dB; adjust (20) FS (A2R101) for 3406A meter reading of 1 on 0 to 1 scale.

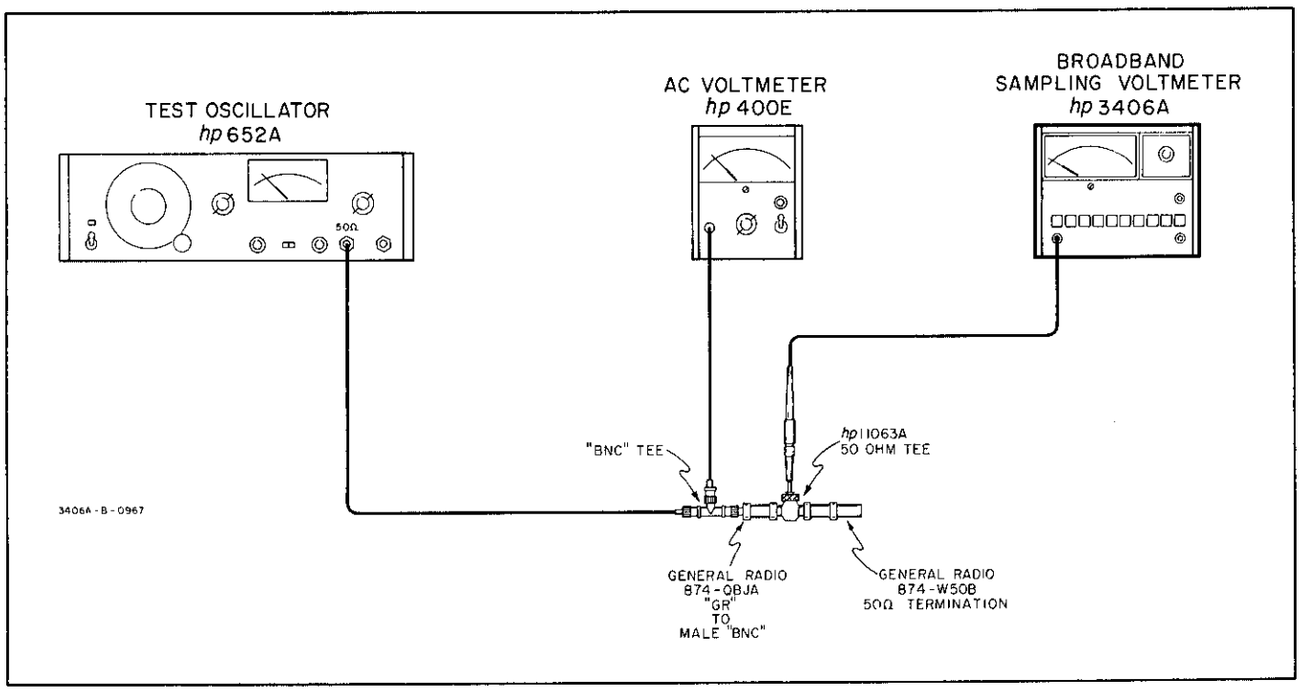


Figure 5-7. Tracking Adjustment Setup

NOTE

Because of interaction between tracking and suppression zero adjustments, repeat meter suppression zero adjustment (Paragraph 5-34) and steps a thru p of this procedure until no interaction is noted between the two adjustments.

5-38. CALIBRATOR OUTPUT ADJUSTMENT. (21)

5-39. No external equipment is required for the calibrator output adjustment.

NOTE

The Signal Amplifier Gain Adjustment, Paragraph 5-30, establishes the 1 volt reference used to adjust the calibrator output in the following procedure. Perform the procedure outlined in Paragraph 5-30 prior to adjusting (21) CALIBRATOR OUTPUT.

a. Insert 3406A probe in 1 VOLT receptacle on front panel; depress 1 volt RANGE pushbutton; depress CAL pushbutton.

b. Adjust (21) CALIBRATOR OUTPUT (A3R2) for 3406A meter indication of 1 on 0 to 1 scale.

5-40. SERVICING.

5-41. The Model 3406A is housed in a box within a box construction to eliminate RFI (radio frequency interference). Within the 3406A the side gussets, the "hinged chassis" and all shields have been treated with a chromate conversion coating. Chromate conversion puts a highly conductive coating on the aluminum metal to prevent oxidation, and aid in shielding against RFI. Avoid scratching the treated surface when working with the Model 3406A.

5-42. GROUNDING.

5-43. Because of the high current pulses used within the Model 3406A and RFI, proper grounding is important. Always note the location of the "ground point" before unsoldering any ground leads, and resolder any ground leads to the same "ground point".

5-44. ETCHED CIRCUIT BOARDS.

5-45. Excluding the Sampling Probe Assembly, the Model 3406A Voltmeter contains two large etched circuit boards designated Top and Bottom Assemblies. The two boards are mounted on the "hinged chassis", illustrated in Table 7-1, with 11 screws -hp- Part No. 2390-0001. An -hp- part number is silk screened on both circuit boards to identify them. See the component location diagrams in Section VII for location of each component mount on the boards, and Section VI for component replacement information.

5-46. The etched circuit boards are a plated-through type. The electrical connections between sides of the board are made with a layer of metal plated-through the component lead holes. To prevent damage to the circuit boards and components, observe the following when soldering.

a. Use a low-heat (25 to 50 watt) small-tip soldering iron, and a small diameter rosin core solder.

b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead, and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component and then remove the leads from the board.

CAUTION

EXCESSIVE OR PROLONGED HEAT CAN LIFT THE CIRCUIT FOIL FROM THE BOARD OR CAUSE DAMAGE TO COMPONENTS.

c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, non-metallic object such as a toothpick.

d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.

e. Clip excess leads off after soldering and clean excess flux from the connection and adjoining area, using type TF Freon (-hp- Part No. 8500-0232).

5-47. To avoid surface contamination the etched circuit boards may be cleaned as outlined below:

a. Clean with a solution of "Finish Dishwashing Detergent" and warm water.

b. Rinse thoroughly with clean water and immediately dry.

CAUTION

WHEN USING ANY ANTI-HUMIDITY SPRAY, THE ETCHED CIRCUIT BOARD PINS AND/OR EXTERNAL CONNECTIONS MUST BE COVERED WITH TAPE OR EQUIVALENT MATERIAL. OTHERWISE, AN INADEQUATE ELECTRICAL CONNECTION TO THE APPROPRIATE CONNECTOR WILL RESULT.

c. When completely dry and properly masked, spray lightly with "General Electric Dry Film 88" anti-humidity spray.

d. The teflon insulators in the gate circuit of the Field Effect Transistors, A2Q7 and A2Q3 should be cleaned with fine wire brush and sprayed lightly with "General Electric Dry Film 88" anti-humidity spray.

5-48. SERVICING THE PROBE ASSEMBLY.

5-49. The Sampling Probe Assembly A1 is not a field repairable item. A complete assembly is available on exchange basis (-hp- Part No. 03406-62103) through your local Hewlett-Packard Sales and Service Office. Perform the step outlined in Paragraph 5-52 to verify proper operation of Sampling Probe Assembly before ordering replacement probe.

5-50. TROUBLESHOOTING PROCEDURES.

5-51. The following troubleshooting procedures are designed to assist in isolating a malfunction(s) within the Model 3406A Voltmeter. These procedures should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures outlined in Paragraph 5-16. An investigation should also be made to ensure that the trouble is not a result of conditions external to the Model 3406A Voltmeter.

NOTE

In addition to the following paragraphs, waveforms and DC voltage levels are shown on the schematic diagrams in Section VII. Use the Functional Block Diagram, Figure 7-1, to isolate the trouble to a particular block.

5-52. TROUBLESHOOTING THE PROBE ASSEMBLY.

5-53. The Sampling Probe is not a field repairable item. A complete assembly is available on an exchange basis under -hp- Part No. 03406-62103. Therefore, the first step in troubleshooting the Model 3406A is to determine if the Sampling Probe is operating properly. To verify proper operation of the probe perform the following steps:

a. Insert the probe into 1 VOLT receptacle and depress CAL and 1 volt RANGE pushbuttons.

b. Remove two Phillips head screws at the rear of the bottom cover and remove the bottom cover.

c. Remove 13 Phillips head screws from the bottom shield and remove it.

d. Remove the probe filter (FL2) shield (Refer to Figure 7-2).

NOTE

The following identifies the function of each signal entering or leaving the Sample Probe Assembly through the Probe Filter Assembly (FL2). The color of wires connected to the feedthrough capacitors on the Probe Filter Assembly are the same on the top as they are on the bottom. (Refer to Figure 7-2).

Wire Color	Function
White	Pulse from Pulse Generator
Orange	Feedback to FET from Stabilizing Ampl
Blue	Sampling probe output
Green	Meter hold
Red	Bridge bias and balance (pos)
Brown	Bridge bias and balance (neg)
Yellow	FET drain

CAUTION

WHEN TAKING MEASUREMENTS AT THE PROBE FILTER DO NOT SHORT OUT THE WHITE WIRE. IF THE WHITE WIRE IS SHORTED DAMAGE TO THE PULSE GENERATOR WILL RESULT.

e. Connect an oscilloscope to the white wire connection on FL2 (J10 pin 6).

f. On oscilloscope observe the pulse from Pulse Generator as shown in Figure 5-8A.

NOTE

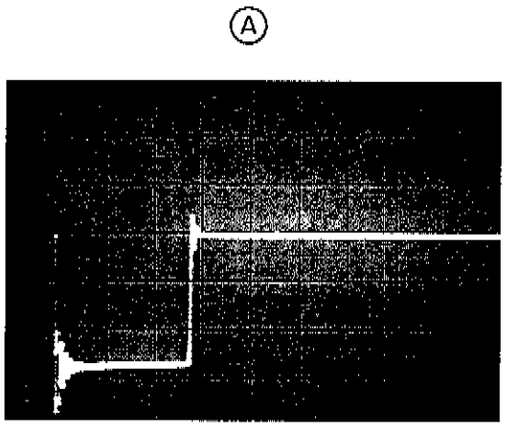
If no pulse is present check the wiring from the top of the probe filter FL2 to the Interconnecting Assembly, and troubleshoot the Pulse Generator circuit shown in Figure 7-8.

g. Connect oscilloscope to the blue wire connection on FL2, J10 pin 8, (sampling probe output).

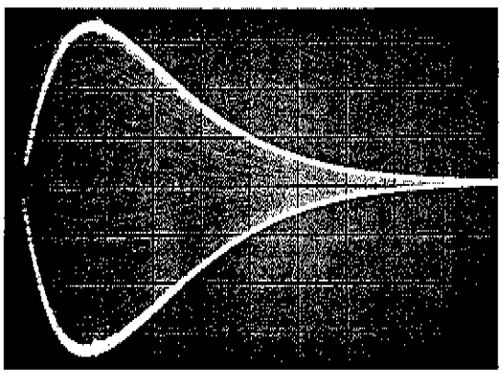
h. Observe the "tear drop" waveform shown in Figure 5-8B.

NOTE

If the "tear drop" waveform is present the Sampling Probe is operating properly. If waveform A in Figure 5-8 (step e) is present and waveform B (step g) is not present, replace the Sampling Probe Assembly according to the following procedures.



White wire on FL2
Ac coupled
Vert = 5 V/cm
Sweep = 1 μsec/cm



Blue wire on FL2
Ac coupled
Vert = .1 V/cm
Sweep = 2 μsec/cm

NOTE

To stop the waveform from sweeping back and forth short the collector of A3Q6 on the Bottom Assembly to ground (see Figure 7-8 for location of A3Q6).

Figure 5-8. Troubleshooting the Probe

5-54. REPLACING THE PROBE ASSEMBLY.

CAUTION

DO NOT PLUG OR UNPLUG THE PROBE FROM J10 WITH THE 3406A TURNED ON.

a. Repeat steps b, c and d in Paragraph 5-53.

b. Unplug the probe connector from its 12 pin connector J10. (See Figure 7-2).

c. Remove the cable clamp (MP17 Figure 6-2) just above the probe connector.

d. Loosen the extra-long nut (MP8 Figure 6-2) behind the front panel, and slide it off the cable. The nut is notched on the inside so that the plug on Probe Connector can fit through it.

e. Save the cable clamp and nut removed in steps c and d for installing the new probe assembly.

f. Install the new or exchange probe assembly by reversing steps d thru a. When replacing the bottom shield, it is important that all of the screws are replaced. Any open holes will degrade the RFI protection provided by the shield.

NOTE

After replacing the Probe Assembly a complete Adjustment and Calibration is required as outlined in Paragraph 5-16.

5-55. TROUBLESHOOTING THE POWER SUPPLY.

5-56. In addition to the DC voltage levels given on the power supply schematic, power supply regulation and ripple checks are given below.

5-57. POWER SUPPLY REGULATION CHECK.

a. A variable power-line transformer (Superior Type VC1M) and dc voltmeter (-hp- Model 414A) are required for this check.

b. On the Top Assembly (A2) connect dc voltmeter between +15 volt test point and the ground test point.

c. With the variable power-line transformer vary the line voltage + and -10% and verify that the dc voltmeter does not vary by more than 0.2 volts from the dc voltage at normal line.

5-58. POWER SUPPLY RIPPLE CHECK.

a. An oscilloscope (-hp- Model 140A/1402A)is required for this test.

b. On the top Assembly (A2) connect an oscilloscope between +15 volt test point and the ground test point.

c. At normal-line voltage the pulses observed

on oscilloscope should be less than 150 mV peak-to-peak.

5-59. TROUBLESHOOTING USING SAMPLE HOLD OUTPUT.

5-60. Because of the circuit location of SAMPLE HOLD OUTPUT Jack, it may be used to divide the instrument into two different sections and isolate the trouble to one of the two sections. Refer to Figure 6-1 for location of SAMPLE HOLD OUTPUT jack. The section prior to SAMPLE HOLD OUTPUT includes the Sample Hold Circuit, Signal Amplifier, Stabilizing Amplifier, Sampling Probe and Pulse Generator Circuits. The section after the SAMPLE HOLD OUTPUT includes the Detector Circuit, Non-linear Meter Circuit and the Meter Damping/Hold Circuit.

5-61. With a known one volt at 1 MHz into the 3406A as outlined in Paragraphs 5-30 and 5-31 the SAMPLE HOLD OUTPUT should be 0.316 ±3%.

NOTE

With a 1 volt sine wave input the SAMPLE HOLD OUTPUT reading will read the same on a true rms voltmeter as it will on an average responding voltmeter. However, if a nonsinusoidal wave is measured the true rms voltmeter reading will differ from the average responding voltmeter.

5-62. TROUBLESHOOTING THE STABILIZING AMPLIFIER LOOP.

5-63. To verify proper operation of the Stabilizing Amplifier perform the following steps.

a. Insert the probe into 1 VOLT receptacle with the CAL pushbutton released (out).

b. Depress .3 volt RANGE pushbutton.

c. Connect oscilloscope to SAMPLE HOLD OUTPUT jack, and set vertical sensitivity to 0.2 V/cm.

d. The SAMPLE HOLD OUTPUT observed on oscilloscope should be a single trace free of any excessive 10 Hz component.

e. Turning the SAMPLE HOLD BIAS (2) both clockwise and counterclockwise, pulses should appear but decline back to a single trace.

NOTE

If the proper results are not received in step e check the continuity of orange wire between Probe Filter FL2 and Interconnecting Assembly before troubleshooting the Stabilizing Amplifier.

CAUTION

THE SAMPLING PROBE IS NOT A FIELD REPAIRABLE ITEM. NEVER DISASSEMBLE THE PROBE. MOVEMENT OF ANY COMPONENT AND/OR CONNECTION WITHIN THE PROBE CAN RESULT IN DAMAGE OR REDUCED PERFORMANCE. REFER TO PARAGRAPH 5-52 AND 5-54 FOR INFORMATION REGARDING THE REPLACEMENT OF THE SAMPLING PROBE ASSEMBLY.

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

6-3. Figure 6-1 illustrates the attaching hardware for Model 3406A; Figure 6-2 illustrates the -hp- Modular Cabinet, and Figure 6-3 illustrates the replaceable mechanical part used in Model 3406A. Miscellaneous and mechanical parts not listed in one of the three figures are listed at the end of Table 6-1 under "Miscellaneous". Figure 6-4 identifies all the Model 3406A accessories in both probe kits and gives the model number or part number for each item.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

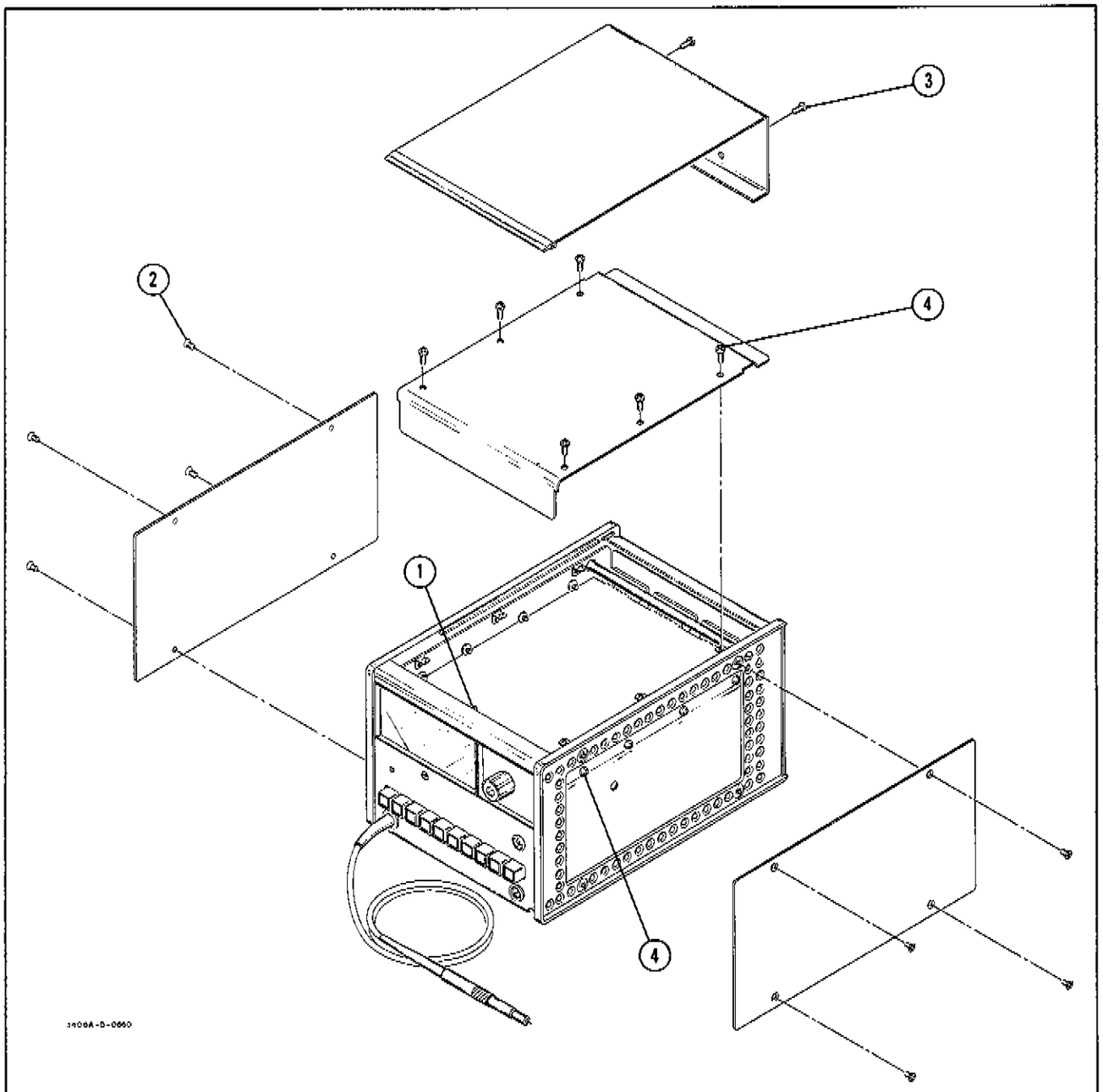
d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor	W	= cable
C	= capacitor	J	= jack	QCR	= transistor-diode	X	= socket
CR	= diode	K	= relay	R	= resistor	XDS	= lampholder
DL	= delay line	L	= inductor	RT	= thermistor	XF	= fuseholder
DS	= lamp	M	= meter	S	= switch	Z	= network
E	= misc electronic part	MC	= microcircuit	T	= transformer		

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent			SPST	= single-pole single-throw
Au	= gold	ins	= insulation (ed)				
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	Ω	= ohm (s)	Ta	= tantalum
cer	= ceramic	kHz	= kilohertz = 10^{+3} hertz	obd	= order by description	TC	= temperature coefficient
coef	= coefficient			OD	= outside diameter	TiO_2	= titanium dioxide
com	= common	L	= inductor				
comp	= composition	lin	= linear taper	p	= peak	tog	= toggle
conn	= connection	log	= logarithmic taper	pc	= printed circuit	tol	= tolerance
dep	= deposited	m	= milli = 10^{-3}	pF	= picofarad (s) = 10^{-12} farads	trim	= trimmer
DPDT	= double-pole double-throw	mA	= milliampere (s) = 10^{-3} amperes	piv	= peak inverse voltage	TSTR	= transistor
DPST	= double-pole single-throw	MHz	= megahertz = 10^{+6} hertz	p/o	= part of	V	= volt (s)
elect	= electrolytic	MΩ	= megohm-(s) = 10^{+6} ohms	pos	= position (s)	vacw	= alternating current working voltage
encap	= encapsulated	met film	= metal film	poly	= polystyrene	var	= variable
F	= farad (s)	mfr	= manufacturer	pot	= potentiometer	vdcw	= direct current working voltage
FET	= field effect transistor	mtg	= mounting	p-p	= peak-to-peak		
fxd	= fixed	mV	= millivolt (s) = 10^{-3} volts	ppm	= parts per million	W	= watt (s)
GaAs	= gallium arsenide	μ	= micro = 10^{-6}	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	w/	= with
GHz	= gigahertz = 10^{+9} hertz	μV	= microvolt (s) = 10^{-6} volts			wiv	= working inverse voltage
gd	= guard (ed)	my	= Mylar ®	R	= resistor	w/o	= without
Ge	= germanium	nA	= nanoampere (s) = 10^{-9} amperes	Rh	= rhodium	ww	= wirewound
grd	= ground (ed)	NC	= normally closed	rms	= root-mean-square	*	= optimum value selected at factory, average value shown (part may be omitted)
H	= henry (ies)	Ne	= neon	rot	= rotary		
Hg	= mercury	NO	= normally open	Se	= selenium	**	= no standard type number assigned (selected or special type)
Hz	= hertz (cycle (s) per second)	NPO	= negative positive zero (zero temperature coefficient)	sect	= section (s)		
				Si	= silicon		



INDEX NO.	DESCRIPTION	QTY.	-hp- PART NO.
(1)	Screw Mach 6-32 x 9/16 SS, with washer lock -hp- Part No. 2190-0008	1	2460-0028
(2)	Screw Mach SS 6-32 x 3/16	8	2370-0020
(3)	Screw Mach SS 6-32 x 1/4	2	2460-0010
(4)	Screw Mach SS 6-32 x 1/4 with washer-lock -hp- Part No. 2190-0008	14	2460-0010

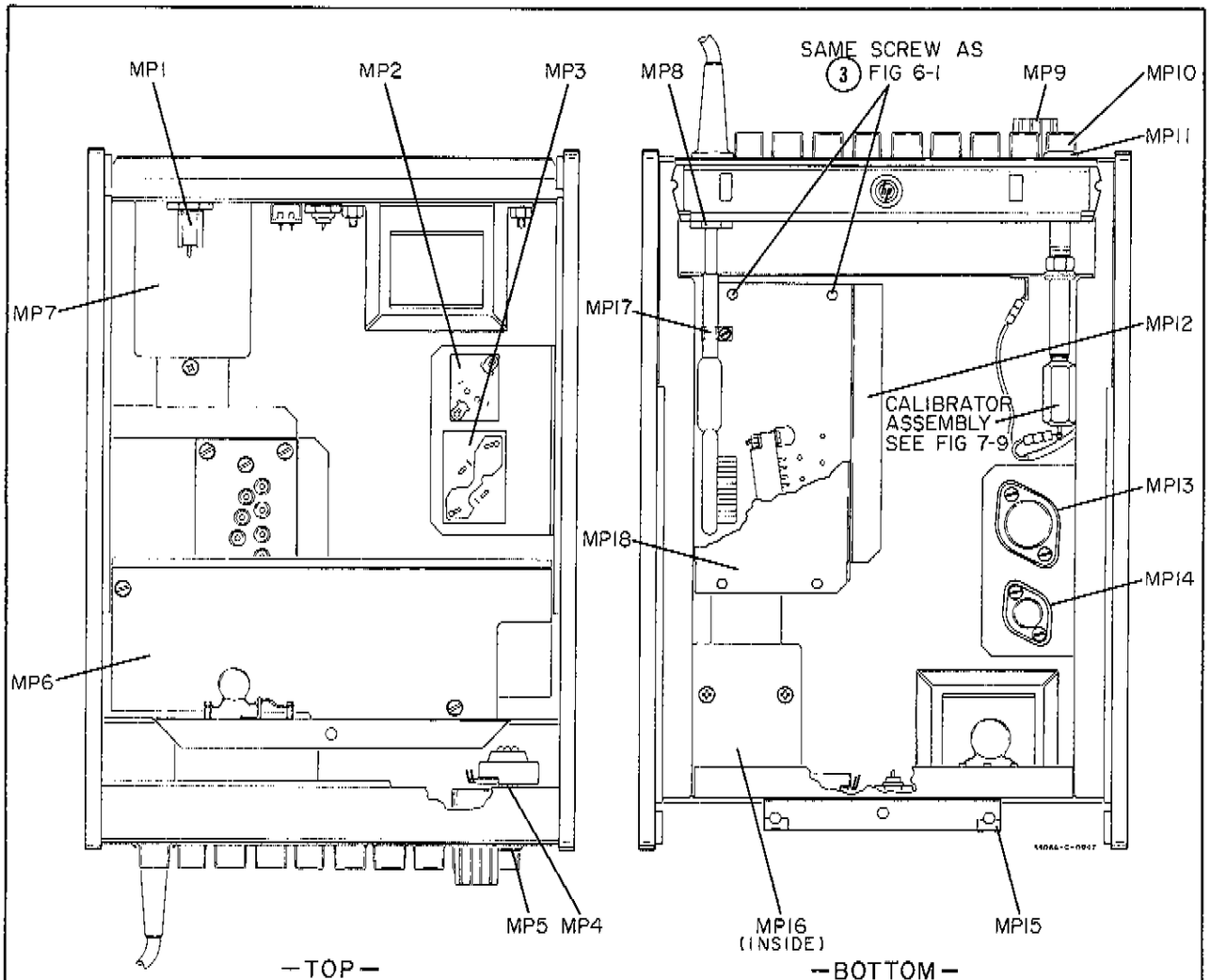
NOTE

The bottom cover is attached with two screws, Mach FH SS 6-32 x 5/16, -hp- Part No. 2370-0016. The bottom shield is attached with 13 screws the same type as No. (4) above.

CAUTION

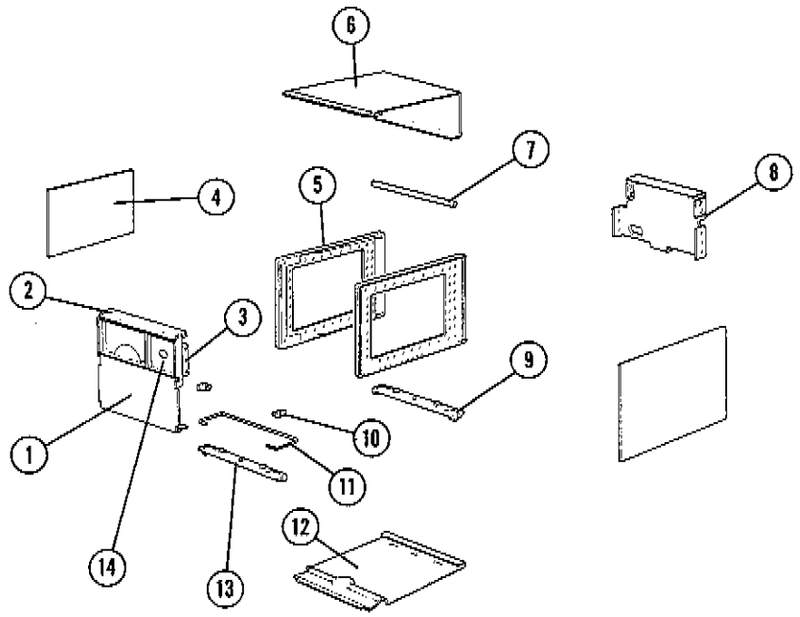
THE TOP COVER SCREWS MUST NOT EXCEED 1/4" IN LENGTH; OTHERWISE, INTERNAL CIRCUITS MAY BE SHORTED.

Figure 6-1. Attaching Hardware



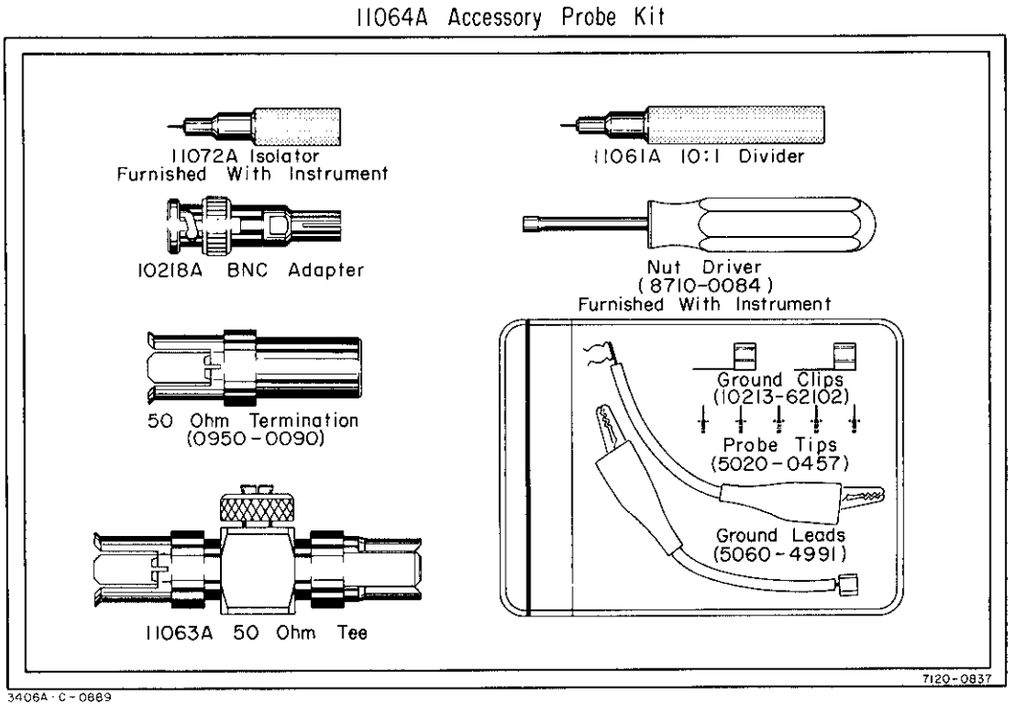
REFERENCE DESIGNATOR	DESCRIPTION	QUANTITY	-hp- PART NO.
MP1	Fuseholder	1	1400-0084
MP2	Socket: TSTR (for Q1)	1	1200-0168
MP3	Socket: TSTR (for Q2)	1	1200-0041
MP4	Bushing: adapter (for CALIBRATE adj)	1	2950-0034
MP5	Bushing: Panel	1	1410-0052
MP6	Shield: range switch	1	03406-00603
MP7	Can: line filter	1	03406-05501
MP8	Nut: boot, probe with washer-lock -hp- Part No. 2190-0037	1	03406-22111
MP9	Knob: 3/4" diameter	1	0370-0025
MP10	Knob: Pushbutton	10	0370-0132
MP11	Bushing: calibrator (1 volt)	1	03406-41702
MP12	Bracket: filter, probe	1	03406-01203
MP13	Insulator: TSTR (for Q2)	1	1200-0077
MP14	Insulator: TSTR (for Q1)	1	0340-0140
MP15	Nut: sheet metal V type 6-32 (tinnerment)	2	0510-0075
MP16	Bracket: line filter	1	03406-01202
MP17	Clamp: probe cable	1	1400-0014
MP18	Shield: filter, probe	1	03406-00604

Figure 6-2. Mechanical Parts



INDEX NO.	DESCRIPTION	QUANTITY	-hp- PART NO.
1	Panel: front	1	03406-00201
2	Meter trim: half module	1	5020-0705
3	Extender: meter case	1	5040-0701
4	Side Cover: 6 x 11 SM	2	5000-0703
5	Frame assembly: 6 x 11 SM	2	5060-0703
6	Top cover assembly: 7 x 11 SM	6	5060-0718
7	Cabinet spacer: half module	1	5020-0701
8	Panel: rear	1	03406-00202
9	Foot assembly: rear 7 x 11 SM	1	241A-44A
10	Hinge	2	5040-0700
11	Stand: tilt	1	1490-0032
12	Bottom cover: 7 x 11 SM	1	5000-0717
13	Foot assembly: front 7 x 11 SM	1	5060-0728
14	Panel: Insert (ZERO)	1	03406-04301

Figure 6-3. Modular Cabinet



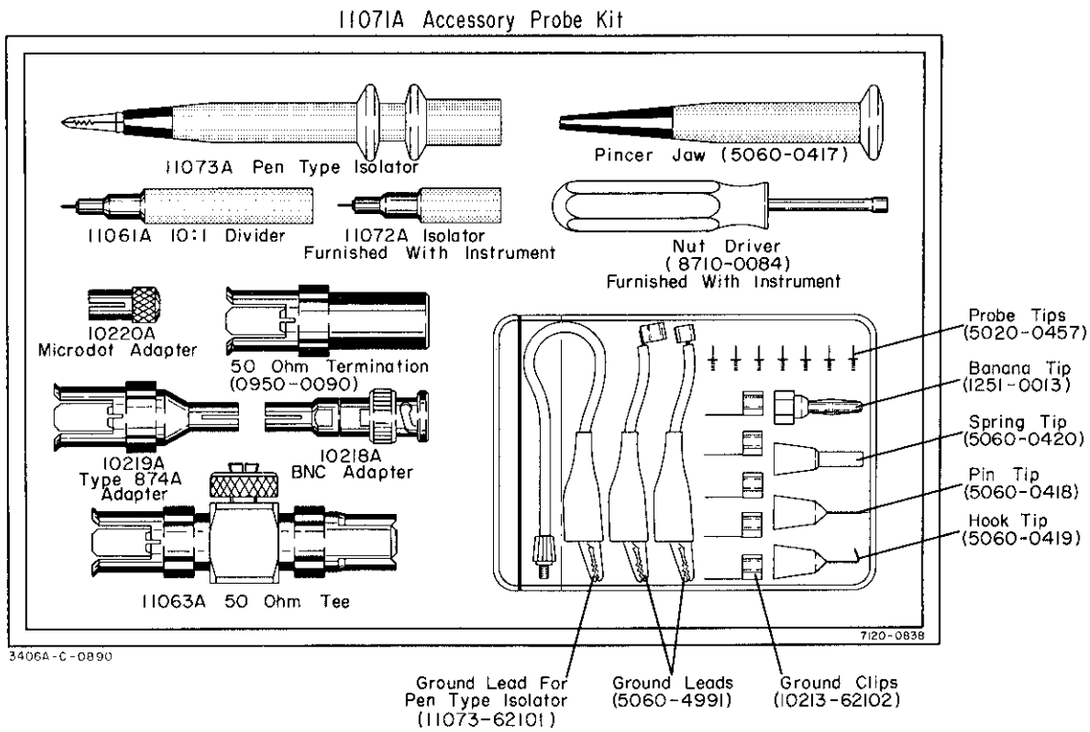


Figure 6-4. Replacement Part No's and Model No's for Accessories

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	03406-66504		1	Assembly: Sampling Probe NOTE A complete Sampling Probe Assembly (A1) is available on an exchange basis under -hp- Part No. 03406-62103. Refer to Section V for procedures outlining the removal and installation of the Sampling Probe Assembly.	28480	03406-62101
A2	03406-66501		1	Assembly: Board, top includes A2C1 thru A2C32 A2Q1 thru A2Q21 A2CR1 thru A2CR22 A2R1 thru A2R118	28480	03406-66501
A2C1	0180-0100		2	C: fxd Ta 4.7 µF ±10% 35 vdcw	56289	150D475X9035B2
A2C2	0180-0155		5	C: fxd Ta 2.2 µF ±20% 20 vdcw	56289	150D225X0020A2
A2C3	0150-0014		3	C: fxd cer 0.005 µF 500 Vdc	04222	D1-4
A2C4	0180-0228		2	C: fxd Ta elect 22 µF ±10% 15 vdcw	56289	150D226X9015B2
A2C5	0150-0084		7	C: fxd cer 0.1 µF +80% -20% 50 vdcw	56289	33C41
A2C6	0140-0152		3	C: fxd mica 1000 pF ±5% 300 vdcw	04062	DM16F102J
A2C7	0180-0106		1	C: fxd Ta 60 µF ±20% 6 vdcw	56289	150D606X0006B2
A2C8	0180-0058		10	C: fxd Al elect 50 µF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A2C9	0150-0084			C: fxd cer 0.1 µF +80% -20% 50 vdcw	56289	33C41
A2C10, A2C11	0150-0096		3	C: fxd cer 0.05 µF +80% -20% 100 vdcw	72982	845-X5V-503Z
A2C12	0140-0152			C: fxd mica 1000 pF ±5% 300 vdcw	04062	DM16F102J
A2C13	0140-0177		1	C: fxd mica 400 pF ±1% 300 vdcw	04062	RDM15F401F3C
A2C14	0140-0208		2	C: fxd mica 680 pF ±5% 300 vdcw	04062	RDM15F681J3C
A2C15	0160-0127		1	C: fxd cer 1 µF ±20% 25 vdcw	56289	5C13
A2C16	0180-0058			C: fxd Al elect 50 µF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A2C17	0180-0224		1	C: fxd Al elect 10 µF +75% -10% 15 vdcw	56289	30D106G015BA4
A2C18	0180-0228			C: fxd Ta elect 22 µF ±10% 15 vdcw	56289	150D226X9015B2
A2C19	0160-0168		2	C: fxd my 0.1 µF ±10% 200 vdcw	56289	192P10492
A2C20	0150-0084			C: fxd cer 0.1 µF +80% -20% 50 vdcw	56289	33C41
A2C21	0180-0058			C: fxd Al elect 50 µF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A2C22, A2C23				Not assigned		
A2C24	0180-0155			C: fxd Ta 2.2 µF ±20% 20 vdcw	56289	150D225X0020A2
A2C25	0180-0058			C: fxd Al elect 50 µF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A2C26	0180-0155			C: fxd Ta 2.2 µF ±20% 20 vdcw	56289	150D225X0020A2
A2C27				Not assigned		
A2C28	0180-0155			C: fxd Ta 2.2 µF ±20% 20 vdcw	56289	150D225X0020A2
A2C29	0180-0100			C: fxd Ta 4.7 µF ±10% 35 vdcw	56289	150D475X9035B2
A2C30	0160-0168			C: fxd my 0.1 µF ±10% 200 vdcw	56289	192P10492
A2C31	0160-0174		1	C: fxd cer 0.47 µF +80% -20% 25 vdcw	56289	5C11B7
A2C32	0160-2018		1	C: fxd mica 250 pF ±5% 500 vdcw	04062	RDM15F251J5S
A2CR1, A2CR2	1902-0049		4	Diode: breakdown 6.19 V ±5% 400 mW	07263	obd
A2CR3	1901-0040		34	Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A2CR4, A2CR5	1901-0033		2	Diode: Si**	28480	1901-0033
A2CR6 thru A2CR12	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A2CR13				Not assigned		
A2CR14	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A2CR15				Not assigned		
A2CR16 thru A2CR22	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2Q1	1854-0071		22	TSTR: Si NPN 2N3391	24446	2N3391
A2Q2	1854-0087		3	TSTR: Si NPN**	24446	obd
			1	Ferrite Bead (for Q2)		
A2Q3 thru A2Q6	1854-0071		1	TSTR: Si NPN 2N3391	24446	2N3391
A2Q7	1855-0025		2	TSTR: Si P-Channel FET	17856	SU 699 obd
A2Q8	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391
A2Q9	1854-0094		2	TSTR: Si NPN 2N3646	07263	obd
A2Q10 thru A2Q12	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391
A2Q13	1853-0016		8	TSTR: Si PNP 2N3638	07263	2N3638
A2Q14, A2Q15	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391
A2Q16	1854-0087		2	TSTR: Si NPN 2N3417	24446	2N3417
A2Q17, A2Q18	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391
A2Q19, A2Q20	1853-0016			TSTR: Si PNP 2N3638	07263	2N3638
A2Q21	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391
A2R1	0687-1031		9	R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R2	0687-2721		4	R: fxd comp 2.7K ±10% 1/2 W	01121	EB 2721
A2R3, A2R4	0687-1821		3	R: fxd comp 1.8K ±10% 1/2 W	01121	EB 1821
A2R5	0687-8231		3	R: fxd comp 82K ±10% 1/2 W	01121	EB 8231
A2R6	0687-2241		2	R: fxd comp 220K ±10% 1/2 W	01121	EB 2241
A2R7	0687-1011		5	R: fxd comp 100Ω ±10% 1/2 W	01121	EB 1011
A2R8	0687-1041		1	R: fxd comp 100K ±10% 1/2 W	01121	EB 1041
A2R9	0687-2241			R: fxd comp 220K ±10% 1/2 W	01121	EB 2241
A2R10	0687-3331		3	R: fxd comp 33K ±10% 1/2 W	01121	EB 3331
A2R11	0687-1831		1	R: fxd comp 18K ±10% 1/2 W	01121	EB 1831
A2R12	0698-3138		2	R: fxd prec met flm 277.5Ω ±1/4% 1/4 W	91637	MFF-1/4 T-O obd
A2R13	0687-6821		6	R: fxd comp 6.8K ±10% 1/2 W	01121	EB 6821
A2R14	0687-3331			R: fxd comp 33K ±10% 1/2 W	01121	EB 3331
A2R15	0687-1821			R: fxd comp 1.8K ±10% 1/2 W	01121	EB 1821
A2R16				Not assigned		
A2R17	0687-5631		2	R: fxd comp 56K ±10% 1/2 W	01121	EB 5631
A2R18	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R19	2100-0095		2	R: var lin 100K ±30%	71450	UPE 70RE -hp-
A2R20	0687-4701		2	R: fxd comp 47Ω ±10% 1/2 W	01121	EB 4701
A2R21 thru A2R23				Not assigned		
A2R24, A2R25	0687-5601		3	R: fxd comp 56Ω ±10% 1/2 W	01121	EB 5601
A2R26	0687-4711		1	R: fxd comp 470Ω ±10% 1/2 W	01121	EB 4711
A2R27	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R28	0687-2221		7	R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221
A2R29	0687-2721			R: fxd comp 2.7K ±10% 1/2 W	01121	EB 2721
A2R30	0687-2721			R: fxd comp 2.7K ±10% 1/2 W	01121	EB 2721
A2R31	0687-2221			R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221
A2R32	0687-1021		7	R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A2R33	0687-4701			R: fxd comp 47Ω ±10% 1/2 W	01121	EB 4701
A2R34	0687-3931		1	R: fxd comp 39K ±10% 1/2 W	01121	EB 2231
A2R35	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R36	0687-2201		3	R: fxd comp 22Ω ±10% 1/2 W	01121	EB 2201
A2R37	0687-8231		10	R: fxd comp 82K ±10% 1/2 W	01121	EB 8231
A2R38	0687-1531		9	R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A2R39	2100-0151		1	R: var lin 500Ω ±20%	71450	UPE 70RE -hp-
A2R40	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A2R41, A2R42	0687-1011			R: fxd comp 100Ω ±10% 1/2 W	01121	EB 1011
A2R43	0687-2711		4	R: fxd comp 270Ω ±10% 1/2 W	01121	EB 2711
A2R44	0687-2221			R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R45	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A2R46	0687-2201			R: fxd comp 22Ω ±10% 1/2 W	01121	EB 2201
A2R47	0687-1541		1	R: fxd comp 150K ±10% 1/2 W	01121	EB 1541
A2R48	0687-8221		5	R: fxd comp 8.2K ±10% 1/2 W	01121	EB 8221
A2R49	0687-2211		3	R: fxd comp 220Ω ±10% 1/2 W	01121	EB 2211
A2R50	0687-8221			R: fxd comp 8.2K ±10% 1/2 W	01121	EB 8221
A2R51	0687-2731		1	R: fxd comp 27K ±10% 1/2 W	01121	EB 2731
A2R52	0686-1645		1	R: fxd comp 160K ±5% 1/2 W	01121	EB 1645
A2R53	0686-3035		1	R: fxd comp 30K ±5% 1/2 W	01121	EB 3035
A2R54	0687-2211			R: fxd comp 220Ω ±10% 1/2 W	01121	EB 2211
A2R55, A2R56	0687-2221			R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221
A2R57	0757-0730		2	R: fxd prec met flm 750Ω ±1% 1/4 W	19701	MF6C T-O obd
A2R58	0687-1521		4	R: fxd comp 1.5K ±10% 1/2 W	01121	EB 1521
A2R59	0687-4721		7	R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A2R60	0757-0764			R: fxd prec met flm 33.2K ±1% 1/4 W	19701	MF6C T-O obd
A2R61	0757-0747		2	R: fxd prec met flm 5.11K ±1% 1/4 W	19701	MF6C T-O obd
A2R62	0757-0764		2	R: fxd prec met flm 33.2K ±1% 1/4 W	19701	MF6C T-O obd
A2R63	0757-0121		1	R: fxd prec met flm 268K ±1% 1/4 W	19701	MF6C T-O obd
A2R64	0687-6831		3	R: fxd comp 68K ±10% 1/2 W	01121	EB 6831
A2R65, A2R66	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A2R67				Not assigned		
A2R68	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A2R69, A2R70	0687-4721			R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A2R71	0698-3212		1	R: fxd prec met flm 249K ±1% 1/4 W	19701	MF6C T-O obd
A2R72	0687-3331			R: fxd comp 33K ±10% 1/2 W	01121	EB 3331
A2R73	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R74	0687-5601			R: fxd comp 56Ω ±10% 1/2 W	01121	EB 5601
A2R75	0757-0753		1	R: fxd prec met flm 9.09K ±1% 1/4 W	19701	MF6C T-O obd
A2R76	0757-0746		2	R: fxd prec met flm 4.75K ±1% 1/4 W	19701	MF6C T-O obd
A2R77	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R78	0757-0730			R: fxd prec met flm 750Ω ±1% 1/4 W	19701	MF6C T-O obd
A2R79	0757-0765		1	R: fxd prec 36.5K ±1% 1/4 W	19701	MF6C T-O obd
A2R80	0757-0340		8	R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O obd
A2R81	2100-0154		3	R: var lin 1K ±30%	71450	UPE 70RE-hp- obd
A2R82	0698-3144		1	R: fxd prec met flm 8.87K ±1% 1/4 W	19701	MF6C T-O obd
A2R83	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O obd
A2R84	2100-0154			R: var lin 1K ±30%	71450	UPE 70RE-hp- obd
A2R85	0698-3283		2	R: fxd prec met flm 9.31K ±1% 1/4 W	19701	MF6C T-O obd
A2R86	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O obd
A2R87	2100-0154			R: var lin 1K ±30%	71450	UPE 70RE-hp- obd
A2R88	0698-3283			R: fxd prec met flm 9.31K ±1% 1/4 W	19701	MF6C T-O obd
A2R89	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O obd
A2R90	2100-0090		1	R: var lin 2K ±30%	71450	UPE 70RE-hp- obd
A2R91	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O obd
A2R92	2100-0095		1	R: var lin 100K ±30%	71450	UPE 70RE-hp- obd
A2R93				Not assigned		
A2R94	2100-0092		3	R: var lin 10K ±20%	71450	UPE 70RE-hp- obd
A2R95	2100-0094		2	R: var lin 50K ±30%	71450	UPE 70RE-hp- obd
A2R96				Not assigned		
A2R97, A2R98	2100-0092			R: var lin 10K ±20%	71450	UPE 70RE-hp- obd
A2R99	2100-0093		1	R: var lin 20K ±20%	71450	UPE 70RE-hp- obd
A2R100	2100-0091		1	R: var lin 5K ±30%	71450	UPE 70RE-hp- obd
A2R101	2100-0094			R: var lin 50K ±30%	71450	UPM 70RE-hp- obd
A2R102	2100-0182		1	R: var lin 3.3K ±10%	71450	UPE 70RE-hp- obd
A2R103	0687-6821			R: fxd comp 6.8K ±10% 1/2 W	01121	EB 6821
A2R104				Not assigned		

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R105	0687-2221			R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221
A2R106	0687-8221			R: fxd comp 8.2K ±10% 1/2 W	01121	EB 8221
A2R107				Not assigned		
A2R108	0687-3321		2	R: fxd comp 3.3K ±10% 1/2 W	01121	EB 3321
A2R109	0687-2721			R: fxd comp 2.7K ±10% 1/2 W	01121	EB 2721
A2R110	0687-6821			R: fxd comp 6.8K ±10% 1/2 W	01121	EB 6821
A2R111	0687-2221			R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221
A2R112	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031
A2R113	0687-2221			R: fxd comp 2.2K ±10% 1/2 W	01121	EB 2221
A2R114	0757-0746			R: fxd prec met flm 4.75K ±1% 1/4 W	19701	MF6C T-O obd
A2R115	0757-0734		1	R: fxd prec met flm 1.21K ±1% 1/4 W	91637	MFF-1/4 T-O obd
A2R116				Not assigned		
A2R117	0757-0728		1	R: fxd prec met flm 619 Ω ±1% 1/4 W	19701	MF6C T-O obd
A2R118	0687-1521			R: fxd comp 1.5K ±10% 1/2 W	01121	EB 1521
A3	03406-66502		1	Assembly: Board, bottom includes A3C1 thru A3C26 A3Q1 thru A3Q20 A3CR1 thru A3CR29 A3R1 thru A3R77 A3K1 A3T1 and A3T2	28480	03406-66502
A3C1	0180-0058			C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A3C2	0160-0153		1	C: fxd 0.001 μF ±10% 200 vdcw	56289	192P10292-PTS
A3C3, A3C4	0160-2348		1	C: set matched my 4 μF ±20% 30 vdcw	56289	Type 148P obd
A3C5	0150-0084			C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41
A3C6	0180-0155			C: fxd Ta 2.2 μF ±20% 20 vdcw	56289	150D225X0020A2
A3C7	0140-0152			C: fxd mica 1000 pF ±5% 300 vdcw	04062	DM16F102J
A3C8	0140-0208			C: fxd mica 680 pF ±5% 300 vdcw	04062	RDM15F681J3C
A3C9	0140-0234		1	C: fxd mica 500 pF ±1% 300 vdcw	04062	RDM15F501F3C
A3C10	0150-0096			C: fxd cer 0.05 μF +80% -20% 100 vdcw	72982	845-X5V-503Z
A3C11	0150-0014			C: fxd cer 0.005 μF 500 vdcw	04222	D1-4
A3C12	0180-0058			C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A3C13	0150-0014			C: fxd cer 0.005 μF 500 vdcw	04222	D1-4
A3C14	0160-0195		1	C: fxd cer 0.001 μF ±20% 250 vacw	56289	19C251A
A3C15	0180-0353		2	C: fxd Al elect 450 μF +100% -10% 50 vdcw	56289	D38702
A3C16	0150-0084			C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41
A3C17, A3C18	0180-0058			C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A3C19	0180-0353			C: fxd Al elect 450 μF +100% -10% 50 vdcw	56289	D38702
A3C20, A3C21	0150-0084			C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41
A3C22, A3C23	0180-0058			C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A3C24, A3C25	0180-0039		2	C: fxd Al elect 100 μF +75% -10% 12 vdcw	56289	30D107G012CC2-DSM
A3C26	0160-0170		1	C: fxd cer 0.22 μF +80% -20% 25 vdcw	56289	5C9A
A3CR1 thru A3CR6	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A3CR7				Not assigned		
A3CR8	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A3CR9	1902-1169		1	Diode: Si breakdown 7.5 V ±5% 250 mW	04713	obd
A3CR10	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A3CR11	1901-0050		1	Diode: Si 200 mA at +1 V 75 V 2 pF 2 ns	07263	FD6195
A3CR12	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
A3CR13, A3CR14	1901-0039		2	Diode: Switching Si 50 piv 200 mA at +1 V 6 pF 8 ns	03877	
A3CR15 thru A3CR18	1901-0026		4	Diode: Rectifier Si 200 piv	04713	SR1358-B

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A3CR19 thru A3CR22	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050	
A3CR23	1902-0049			Diode: breakdown 6.19 V ±5% 400 mW	07263	obd	
A3CR24	1902-0761		1	Diode: breakdown 6.2 V ±0.01% IN821	04713	IN821	
A3CR25 thru A3CR28	1901-0040			Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050	
A3CR29	1902-0049			Diode: breakdown 6.19 V ±5% 400 mW	07263	obd	
A3K1	0490-0180		1	Relay: form C 12 Vdc	80089	61-146	
A3Q1	1854-0005		1	TSTR: Si NPN 2N708	02735	obd	
A3Q2	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391	
A3Q3	1855-0025			TSTR: Si P-Channel FET	17856	SU 699	obd
A3Q4	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391	
A3Q5	1853-0016			TSTR: Si PNP 2N3638	07263	2N3638	
A3Q6 thru A3Q8	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391	
A3Q9	1853-0016			TSTR: Si PNP 2N3638	07263	2N3638	
A3Q10	1855-0010		1	TSTR: Si 2N2646 uni junction	24446	obd	
	1205-0018		1	Heat sink: for transistor A3Q10	05820	NF-203	
A3Q11	1854-0005		1	TSTR: Si NPN 2N708	01295	2N708	
A3Q12	1854-0094			TSTR: Si NPN 2N3646	07263	obd	
A3Q13	1853-0016			TSTR: Si PNP 2N3638	07263	2N3638	
A3Q14	1854-0087			TSTR: Si NPN 2N3417	24446	2N3417	
A3Q15, A3Q16	1854-0071			TSTR: Si NPN 2N3391	24446	2N3391	
A3Q17	1853-0020		1	TSTR: Si PNP	01295	SM-9143	
A3Q18, A3Q19	1853-0016			TSTR: Si PNP 2N3638	07263	2N3638	
A3Q20	1854-0003		1	TSTR: Si NPN 2N1711	81453	RT5299	
A3R1	0757-0732		1	R: fxd prec met flm 909Ω ±1% 1/4 W	19701	MF6C T-O	obd
A3R2	2100-1434		2	R: var lin 1K ±30%	71450	XQS 200	
A3R3	0757-0750		1	R: fxd prec met flm 6.81K ±1% 1/4 W	19701	MF6C T-O	obd
A3R4	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB1031	
A3R5	0687-2211			R: fxd comp 220Ω ±10% 1/2 W	01121	EB 2211	
A3R6	0687-2201			R: fxd comp 22Ω ±10% 1/2 W	01121	EB2201	
A3R7	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531	
A3R8	2100-1434			R: var lin 1K ±30%	71450	XQS 200	
A3R9	0687-6821			R: fxd comp 6.8K ±10% 1/2 W	01121	EB 6821	
A3R10	0687-2711			R: fxd comp 270Ω ±10% 1/2 W	01121	EB 2711	
A3R11	0757-0344		2	R: fxd prec met flm 1M ±1% 1/4 W	19701	MF6C T-O	obd
A3R12	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O	obd
A3R13	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031	
A3R14	0687-6801		1	R: fxd comp 68Ω ±10% 1/2 W	01121	EB 6801	
A3R15	0687-5621		1	R: fxd comp 5.6K ±10% 1/2 W	01121	EB 5621	
A3R16	2100-1435		1	R: var lin 3.3K ±10%	71450	QS 200	
A3R17				Not assigned			
A3R18	0687-4731		1	R: fxd comp 47K ±10% 1/2 W	01121	EB 4731	
A3R19	0687-6821			R: fxd comp 6.8K ±10% 1/2 W	01121	EB 6821	
A3R20	0687-1821			R: fxd comp 1.8K ±10% 1/2 W	01121	EB 1821	
A3R21	0757-0344			R: fxd prec met flm 1M ±1% 1/4 W	19701	MF6C T-O	obd
A3R22	0687-1031			R: fxd comp 10K ±10% 1/2 W	01121	EB 1031	
A3R23	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O	obd
A3R24	0687-5611		4	R: fxd comp 560Ω ±10% 1/2 W	01121	EB 5611	
A3R25	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O	obd
A3R26	0757-0747			R: fxd prec met flm 5.11K ±1% 1/4 W	19701	MF6C T-O	obd
A3R27				Not assigned			
A3R28	0687-6811		2	R: fxd comp 680Ω ±10% 1/2 W	01121	EB 6811	
A3R29	0687-8221			R: fxd comp 8.2K ±10% 1/2 W	01121	EB 8221	
A3R30	0687-6831			R: fxd comp 68K ±10% 1/2 W	01121	EB 6831	

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3R31	0687-8221			R: fxd comp 8.2K ±10% 1/2 W	01121	EB 8221
A3R32	0687-6831			R: fxd comp 68K ±10% 1/2 W	01121	EB 6831
A3R33	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A3R34	0687-5631			R: fxd comp 56K ±10% 1/2 W	01121	EB 5631
A3R35	0687-4721			R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A3R36, A3R37	0686-1035		2	R: fxd comp 10K ±5% 1/2 W		
A3R38	0686-9125		1	R: fxd comp 9.1K ±5% 1/2 W	01121	EB 9125
A3R39	0687-1021			R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A3R40	0757-0340			R: fxd prec met flm 10K ±1% 1/4 W	19701	MF6C T-O obd
A3R41	0687-3321			R: fxd comp 3.3K ±10% 1/2 W	01121	EB 3321
A3R42	0687-5611			R: fxd comp 560Ω ±10% 1/2 W	01121	EB 5611
A3R43	0687-1011			R: fxd comp 100Ω ±10% 1/2 W	01121	EB 1011
A3R44	0687-1021			R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A3R45	0687-4721			R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A3R46	0687-1521			R: fxd comp 1.5K ±10% 1/2 W	01121	EB 1521
A3R47 thru A3R49	0757-1000		3	R: fxd prec met flm 51.1Ω ±1% 1/2 W	91637	MFF 1/2 T-O obd
A3R50	0687-4721			R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A3R51	0687-1021			R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A3R52	0698-3559		1	R: fxd comp 3.9Ω ±10% 1/2 W	01121	EB 39G1
A3R53	0687-1521			R: fxd comp 1.5K ±10% 1/2 W	01121	EB 1521
A3R54	0687-5611			R: fxd comp 560Ω ±10% 1/2 W	01121	EB 5611
A3R55	0687-1021			R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A3R56	0687-1011			R: fxd comp 100Ω ±10% 1/2 W	01121	EB 1011
A3R57, A3R58	0698-4052		2	R: fxd prec met flm 6.98K ±1% 1/4 W	19701	MF6C T-O obd
A3R59	0687-4721			R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A3R60	0687-1221		1	R: fxd comp 1.2K ±10% 1/2 W	01121	EB 1221
A3R61	0698-4059		1	R: fxd comp 5.6Ω ±10% 1/2 W	01121	EB 56G1
A3R62	0687-6811			R: fxd comp 680Ω ±10% 1/2 W	01121	EB 6811
A3R63	0687-1021			R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A3R64	0687-5611			R: fxd comp 560Ω ±10% 1/2 W	01121	EB 5611
A3R65	0687-1011			R: fxd comp 100Ω ±10% 1/2 W	01121	EB 1011
A3R66	0757-0339		1	R: fxd prec met flm 3.01K ±1% 1/4 W	19701	MF6C T-O obd
A3R67	2100-0365		1	R: var lin 500Ω ±30%	71450	XQS-200
A3R68	0757-0745		1	R: fxd prec met flm 4.32K ±1% 1/4 W	19701	MF6C T-O obd
A3R69	0687-3311		2	R: fxd comp 330Ω ±10% 1/2 W	01121	EB 3311
A3R70	2100-0362		1	R: var lin 100K ±30%	71450	XQS-200
A3R71	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A3R72	2100-1436		1	R: var lin 10K ±30%	71450	QS200
A3R73	0687-1531			R: fxd comp 15K ±10% 1/2 W	01121	EB 1531
A3R74, A3R75	0687-4721			R: fxd comp 4.7K ±10% 1/2 W	01121	EB 4721
A3R76	0687-1021			R: fxd comp 1K ±10% 1/2 W	01121	EB 1021
A3R77	0687-6821			R: fxd comp 6.8K ±10% 1/2 W	01121	EB 6821
A3T1	9100-1338		1	Transformer: pulse	28480	9100-1338
A3T2	9100-1323		1	Transformer: pulse	28480	9100-1323
C1	0180-0058			C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C2	0150-0012		1	C: fxd cer 0.01 μF ±20% 1000 vdcw	56289	29C214A3
C3	0150-0052		1	C: fxd cer 0.05 μF ±20% 400 vdcw	56289	33C17A
DS1	2140-0015		1	Lamp: neon pilot	24455	A-165
F1	2110-0018		1	Fuse: 0.25 amps 125 V slow-blow	75915	313.250

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
FL1	03406-66506		1	Assembly: line filter includes FL1C1 thru FL1C6 FL1R1 thru FL1R4 FL1L1 and FL1L2 Also includes J1 of main chassis	28480	03406-62701
	9170-0016		9	Bead: ferrite shielding	02114	56-590-65A1/3B
FL1C1 thru FL1C4	0150-0086		1	C: fxd cer 0.0047 μF 500 vdcw	04222	D1-4
FL1C5, FL1C6	0150-0069		2	C: fxd cer 0.001 μF 500 vdcw	72982	801-010X5G0102Z
FL1L1, FL1L2	9100-1331		2	Inductor: fxd 3 mH	28480	9100-1331
FL1R1, FL1R2	0684-1021		3	R: fxd comp 1K ±10% 1/4 W	01121	CB 1021
FL1R3, FL1R4	0687-3311			R: fxd comp 330Ω ±10% 1/2 W	01121	EB 3311
FL2	03406-66507		1	Assembly: probe filter includes FL2C1 thru FL2C7	28480	03406-66507
FL2C1, FL2C2	0160-2360		4	C: fxd cer 100 pF ±10% 300 vdcw	01121	FUGD
FL2C3 thru FL2C7	0160-2361		5	C: fxd cer 470 pF ±10% 300 vdcw	01121	FUGD
FL3	03406-63202		1	Assembly: filter calibrator includes FL3C1 and FL3C2 FL3R1	28480	03406-63202
FL3C1, FL3C2	0160-2360			C: fxd cer 100 pF ±10% 300 vdcw	01121	FUGD
FL3R1	0684-1021			R: fxd comp 1K ±10% 1/4 W	01121	CB 1021
J1	1251-0148		1	Connector: ac power cord receptacle	82389	AC3G
J2, J3	1250-0083		2	Connector: BNC	95712	30624-1
J4 thru J7	1251-0478			Connector: pc 12 pin	07233	64-718-6
J8, J9	1251-0472		2	Connector: pc 12 pin	07233	65-716
J10	1251-0478		5	Connector: pc 12 pin	07233	64-718-6
M1	1120-0393		1	Meter: flush	28480	1120-0393
Q1	1854-0072		1	TSTR: Si NPN 2N3054	86684	2N3054
Q2	1850-0190		1	TSTR: Ge PNP 2N2138	04713	2N2138
R1	2100-1801		1	R: var comp lin 25K ±30% 1/3 W	71450	5VA-45
R2	2100-0407		1	R: var ww lin 5K ±10%	71450	Series AW obd
R3	0684-3331		1	R: fxd comp 33K ±10% 1/4 W	01121	CB 3331
R4	2100-0136		1	R: var lin 6K ±20%	71450	Type 70 obd
S1	03406-61901		1	Assembly: switch range includes S1R1 thru S1R14	28480	03406-61901
S1R1	0698-4162		1	R: fxd prec met flm 30.79Ω ±1/4% 1/4 W	91637	MFF-1/4 T-O obd
S1R2	0698-4163		1	R: fxd prec met flm 128.1Ω ±1/4% 1/4 W	91637	MFF-1/4 T-O obd
S1R3	0687-1511		1	R: fxd prec comp 150Ω ±10% 1/2 W	01121	EB 1511
S1R4 thru S1R8	0698-3139		5	R: fxd prec met flm 410.26Ω ±1/4% 1/4 W	91637	MFF-1/4 T-O obd
S1R9 thru S1R12	0698-3138			R: fxd prec met flm 277.5 ±1/4% 1/4 W	91637	MFF-1/4 T-O obd
S1R13	0698-3137		1	R: fxd prec met flm 189.7Ω ±1/4% 1/4 W	91637	MFF-1/4 T-O obd
S1R14	0687-1831			R: fxd comp 18K ±10% 1/2 W	01121	EB 1831
S2	3101-0033		1	Switch: slide DPDT (115-230 vac)	42190	4633
T1	9100-1322		1	Transformer: power	28480	9100-1322

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
				MISCELLANEOUS		
	03406-66503		1	Assembly: board interconnecting	28480	03406-66503
	8120-0078		1	Assembly: cable power smooth black extra limp 7.5 ft long	70903	KH-4147
	03406-63201		1	Assembly: calibrator (includes all parts for the 1 VOLT receptacle)	28480	03406-63201
	03406-62102		1	Assembly: housing probe	28480	03406-62102
	5040-0235		1	Base: lampholder (for DS1)	28480	5040-0235
	9170-0016		20	Bead: ferrite	02114	56-590-65/3B
	03406-26505		1	Board: probe connector	28480	03406-26505
	03406-01202		1	Bracket: line filter (FL1)	28480	03406-01202
	2950-0034		1	Bushing: adapter (for CALIBRATE ADJ)	000LF	obd
	03406-41702		1	Bushing: calibrate (on front panel)	28480	03406-41701
	1410-0052		1	Bushing: panel (for CALIBRATE ADJ)	95264	obd
	03406-05501		1	Can: line filter (FL1)	28480	03406-05501
	03406-00101		1	Chassis: hinged	28480	03406-00101
	10213-62102		2	Clip: ground	28480	10213-62102
	5000-0717		1	Cover: bottom 7 x 11 submodule	28480	5000-0717
	5000-0703		2	Cover: side 6 x 11 submodule	28480	5000-0703
	5060-0718		1	Cover: top 7 x 11 submodule	28480	5060-0718
	5040-0701		1	Extender: meter case	28480	5040-0701
	241A-44A		1	Foot Assembly: 7 x 11 submodule	28480	241A-44A
	5060-0728		1	Foot Assembly: 7 x 11 submodule	28480	5060-0728
	5060-0703		2	Frame Assembly: 6 x 11 submodule	28480	5060-0703
	1400-0084		1	Fuseholder	75915	342014
	03406-01101		1	Heat sink: TSTR (for Q1 and Q2)	28480	03406-01101
	5040-0700		2	Hinge: (for tilt stand)	28480	5040-0700
	0340-0060		3	Insulator: cloverleaf feed-thru teflon (used on A2 and A3 assemblies)	98291	FT-E-15
	03406-22112		1	Insulator: housing probe	28480	03406-22112
	0340-0140		1	Insulator: transistor	02735	DF 31A
	1200-0077		1	Insulator: transistor	16037	112 obd
	0370-0132		10	Knob: pushbutton (RANGE)	28480	0370-0132
	0370-0025		1	Knob: round black 3/4" diam (ZERO)	28480	0370-0025
	5000-0252		1	Label: pushbutton (OFF)	28480	5000-0252
	5000-3220		1	Label: pushbutton .001 -50	28480	5000-3220
	5000-3221		1	Label: pushbutton .003 -40	28480	5000-3221
	5000-3222		1	Label: pushbutton .01 -30	28480	5000-3222
	5000-3223		1	Label: pushbutton .03 -20	28480	5000-3223
	5000-3224		1	Label: pushbutton .1 -10	28480	5000-3224
	5000-3225		1	Label: pushbutton .3 0	28480	5000-3225
	5000-3226		1	Label: pushbutton 1 10	28480	5000-3226
	5000-3244		1	Label: pushbutton 3 20	28480	5000-3244
	5000-3243		1	Label: pushbutton (CAL)	28480	5000-3243
	5060-4991		1	Lead: ground	28480	5060-4991
	5040-0234		1	Lampholder: (for DS1)	28480	5040-0234
	03406-90001		1	Manual: operating and service	28480	03406-90001

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	5020-0705		1	Meter trim: submodule	28480	5020-0705
	03406-22111		1	Nut: boot probe	28480	03406-22111
	8710-0084		1	Nut driver: hex	96508	P-3 obd
	03406-00201		1	Panel: front	28480	03406-00201
	03406-04301		1	Panel: insert	28480	03406-04301
	03406-00202		1	Panel: rear	28480	03406-00202
	03406-00203		1	Panel: sub rear	28480	03406-00203
	03406-00601		1	Shield: bottom cover	28480	03406-00601
	03406-00604		1	Shield: probe filter cover	28480	03406-00604
	03406-00603		1	Shield: range switch cover	28480	03406-00603
	03406-22113		1	Shield: switch part of 03406-62102 see pc 9-1968	28480	03406-22113
	03406-00602		1	Shield: top cover	28480	03406-00602
	1200-0168		1	Socket: TSTR (for Q1)	000LK	PTS-4 obd
	1200-0041		1	Socket: TSTR (for Q2)	71785	133-32-10-013
	1490-0032		1	Stand: tilt submodule	91260	obd
	7124-0339		1	Tag: red operating note	28480	7124-0339
	5020-0457		10	Tip: pin probe	28480	5020-0457
	11072-60001		1	Tip: isolator	28480	11072-60001

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 3406A Broadband Sampling Voltmeter. Included is Table 7-1, with photograph of the instrument, identifying the various assemblies.

7-3. COVER REMOVAL.

7-4. To prepare the instrument for calibration or to make the components or test points on the top or bottom assemblies accessible perform the steps outlined in Figure 7-1.

7-5. FUNCTIONAL BLOCK DIAGRAM.

7-6. The functional block diagram shows the relationship between the assemblies of the instrument. Signal flow between assemblies and significant portions of assemblies as well as major feedback paths are shown. The functional block diagram is used to isolate trouble to a particular block. Test points, voltage waveforms, and voltage levels are identified on the functional block diagram.

7-7. COMPONENT LOCATION DIAGRAMS.

7-8. The component location diagrams show the physical location of parts mounted on an assembly. The components mounted on the chassis of the instrument are identified in Figure 7-2.

7-9. INTERCONNECTING ASSEMBLY.

7-10. The top and bottom assemblies are connected to each other and other circuits through the interconnecting assembly shown in Figure 7-3.

7-11. SCHEMATIC DIAGRAMS.

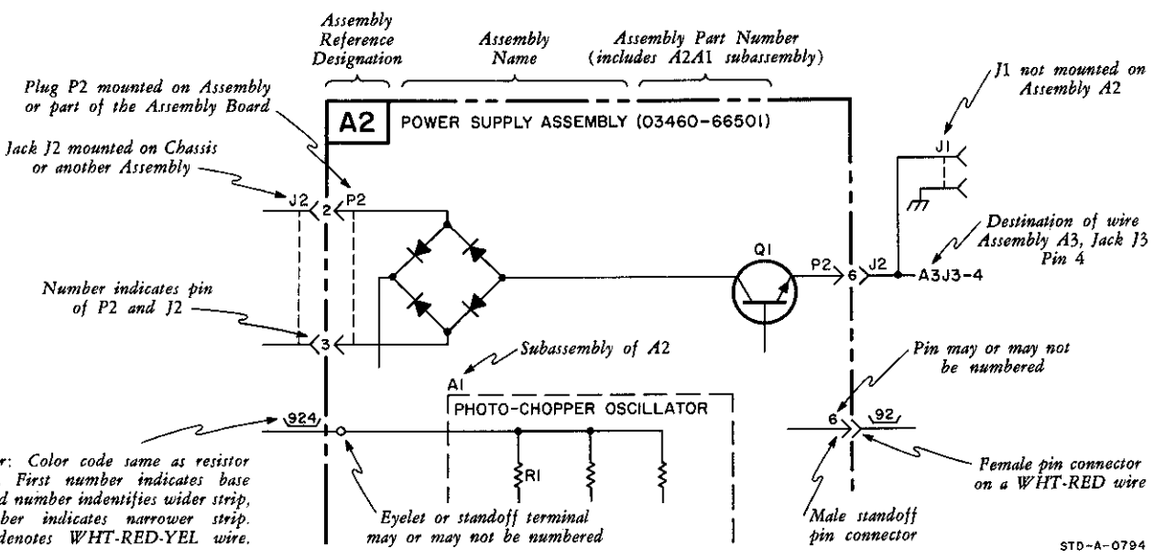
7-12. The circuits contained within each assembly are shown in a schematic diagram. These diagrams are used to develop an understanding of the detail theory of operation and as an aid in isolating a malfunction to a component(s). To aid in troubleshooting dc voltage levels and waveform test points are given in red on each schematic.

7-13. An explanation of terms and symbols used on schematic diagrams is given below.

REFERENCE DESIGNATIONS

PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

ASSEMBLY	SUBASSEMBLY	COMPONENT	COMPLETE DESIGNATION
A2	NONE	Q1	A2Q1
A2	A1	R1	A2A1R1
NONE	NONE	J1	J1


Assembly Reference Designation
Assembly Name
Assembly Part Number (includes A2A1 subassembly)
Plug P2 mounted on Assembly or part of the Assembly Board
A2
POWER SUPPLY ASSEMBLY (03460-6650I)
J1 not mounted on Assembly A2
Jack J2 mounted on Chassis or another Assembly
J2
P2
J1
Destination of wire Assembly A3, Jack J3 Pin 4
Q1
P2
6
J2
A3J3-4
Number indicates pin of P2 and J2
3
Subassembly of A2
A1
PHOTO-CHOPPER OSCILLATOR
Pin may or may not be numbered
924
6
92
Wire Color: Color code same as resistor color code. First number indicates base color, second number indentifies wider strip, third number indicates narrower strip. E.g. 924 denotes WHT-RED-YEL wire.
R1
Female pin connector on a WHT-RED wire
Eyelet or standoff terminal may or may not be numbered
Male standoff pin connector
STD-A-0794

MANUAL BACKDATING CHANGES

MODEL 3406A

BROADBAND SAMPLING VOLTMETER

Manual backdating changes describe changes necessary to adapt this manual to earlier instruments. The backdating changes are listed in the following table according to instrument serial number or serial prefix.

Instrument component values that differ from those in the manual, yet are not listed in the Backdating Changes should be replaced with the part number given in Section VI of this manual.

Instrument Serial Prefix	Make Manual Changes
625-00475 and below	1 No. 2
606-00325 and below	1
606-00250 and below	1 thru 3
606-00200 and below	1 thru 4

Instrument Serial Prefix	Make Manual Changes
606-00150 and below	1 thru 5
606-00148 and below	1 thru 6

CHANGE #1 (Ref. Service Note 3406A-5)

1. Change A3R56 and A3R65 in the Power Supply Circuit to 270Ω ±10% 1/2 W (-hp- Part No. 0687-2711).

NOTE

If any one of the above resistors fail, or if power supply oscillations are observed, replace both resistor with 100Ω resistor identified in Table 6-1.

2. Change A3R28 to 680Ω (-hp- Part No. 0687-6811) to prevent recorder output loading.

CHANGE #2 (Ref. Service Note 3406A-2)

NOTE

Do not make Change #2 for the following instruments:

606-00201 thru 606-00203	606-00232	606-00240
606-00206 thru 606-00208	606-00234	606-00241
606-00231	606-00237	606-00243

1. Remove ferrite bead ($\bar{\bar{Q}}$) in emitter circuit of A2Q2.

NOTE

If A2Q2 fails or starts to oscillate replace it with Part No. listed in Table 6-1 and add a ferrite bead (-hp- Part No. 9170-0016) around the emitter lead.

2. Change the following resistors in the Pulse Generator Circuit:

A3R36 to 22K ±10% 1/2 W (-hp- Part No. 0687-2231).
A3R37 to 10K ±10% 1/2 W (-hp- Part No. 0687-1031).
A3R38 to 12K ±10% 1/2 W (-hp- Part No. 0687-1231).

NOTE

If any one of the resistors above fail, or if a dip in frequency response occurs at 20 kHz, replace all three resistors with parts identified in Table 6-1.

CHANGE #3 (Ref Service Note 3406A-3)

NOTE

Do not make Change #3 for the following instruments:

606-00203	606-00211	606-00215	606-00224	606-00235
606-00204	606-00212	606-00221	606-00228	606-00240
606-00208	606-00213	606-00222	606-00233	606-00246
606-00209	606-00214	606-00223	606-00234	606-00247
				606-00248

Manual Backdating Changes

CHANGE #3 (Cont'd) 1. Change S1R14 and A2R34 in the Stabilizing Amplifier Circuit to 6.8K ±10% 1/2 W (-hp- Part No. 0687-6821) and 22K ±10% 1/2 W (-hp- Part No. 0687-2231) respectively.

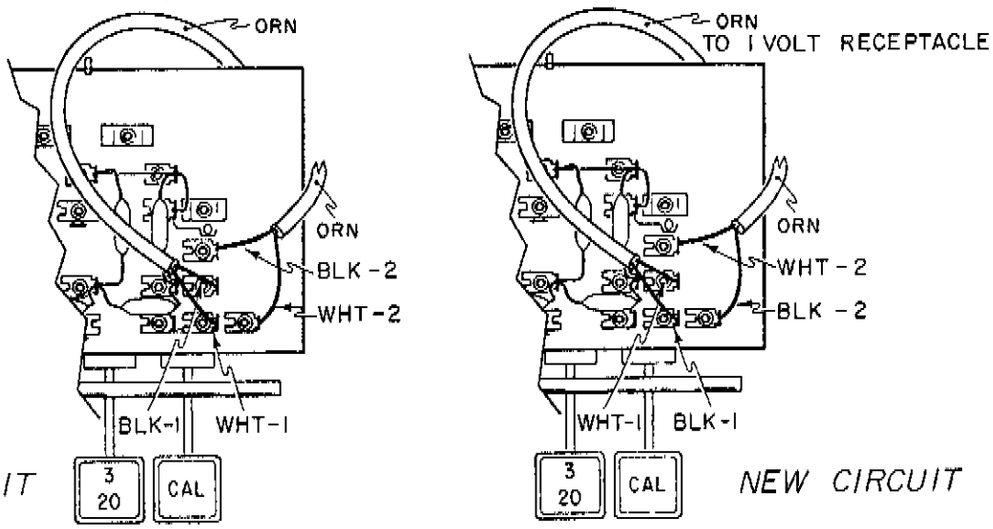
NOTE

The value of S1R14 and A2R34 determines the Stabilizing Amplifier compensation and loop stability. If either resistor fails or if a ripple in the frequency response occur below 50 kHz replace both resistors with the parts identified in Table 6-1.

CHANGE #4 1. All instruments 606-00200 and below should be changed to the "new" CAL pushbutton wiring shown below. This change will eliminate any ground loops when the CAL pushbutton is depressed, and make the wiring agree with the present schematic diagram.

NOTE

Some of the instruments may have been changed at the factory.



CHANGE #5 1. Change A2R101 and A2R112 in the Non-linear Gain Adjust circuit to 20K ±20% (-hp- Part No. 2100-0093) and 18K ±10% 1/2 W (-hp- Part No. 0687-1831) respectively.

NOTE

To increase the range of the 30 MV FS TRACKING adjustment, replace both A2R101 and A2R112 with the parts identified in Table 6-1.

CHANGE #6

NOTE

Do not make Change #6 for the following instruments:

606-00101 thru 606-00103	606-00122	606-00133
606-00107 thru 606-00111	606-00123	606-00137
606-00115	606-00127	606-00138
606-00116	606-00129	606-00141
606-00118	606-00131	606-00144

1. Change A3R7 and A3C2 in the Calibration circuit to 10K ±10% 1/2 W (-hp- Part No. 0687-1031) and 0.0068 μF ±10% 200 vdcw. (-hp- Part No. 0160-0159).

NOTE

The front panel calibration accuracy may be improved by changing the resistor A3R7 and capacitor A3C7 to 15K ±10% 1/2 W (-hp- Part No. 0687-1531) and 0.001 μF ±10% (-hp- Part No. 0160-0153). If this change is made it will also be necessary to make change #4.

GENERAL SCHEMATIC NOTES

1. ALL DC VOLTAGE LEVELS SHOWN ON SCHEMATICS ARE TYPICAL AND MAY VARY FROM INSTRUMENT TO INSTRUMENT.
2. REFERENCE DESIGNATOR OR COMPONENTS SCREENED IN RED DENOTE BACKDATING CHANGE SEE PAGES 7-2 AND 7-3.
3. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATIONS(S) OR BOTH FOR COMPLETE DESIGNATION.
4. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.

   RESISTANCE IN OHMS.

   CAPACITANCE IN MICROFARADS.

5. ⏚ DENOTES POWER LINE GROUND.
6. ▽ DENOTES GROUND ON ETCHED CIRCUIT BOARD.
7. ——— – – ——— DENOTES ASSEMBLY.
8. ——————— DENOTES MAIN SIGNAL PATH.
9. — — — — — DENOTES DC FEEDBACK PATH.
10. —●—●—●— DENOTES AC FEEDBACK PATH.
11. ▭ DENOTES FRONT PANEL MARKING.
12. ⬚ DENOTES REAR PANEL MARKING.
13. DENOTES SCREWDRIVER ADJUST.
14. \924/ DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e. g. \924/ = WHITE, RED, YELLOW.)
15. DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
16. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
17. ALL RELAYS ARE SHOWN DEENERGIZED.
18. DENOTES FERRITE BEADS.
19. DENOTES SECOND APPEARANCE OF A CONNECTOR PIN.

Table 7-1. Model 3406A Assembly Designations

REFERENCE DESIGNATION	TITLE	-hp- PART NO.	SCHEMATIC LOCATION
A1	Sampling Probe Assembly	03406-66504	Page 7-11
A2	Top Assembly	03406-66501	Page 7-11, 7-13
A3	Bottom Assembly	03406-66502	Page 7-11, 7-13, 7-15, 7-16 and 7-17
S1	Range Switch Assembly	03406-61901	Page 7-11, 7-13, 7-16, and 7-17

NOTE

All components not located on one of the above assemblies are considered part of the "main" assembly and are not prefixed with an assembly reference designator.

PROBE REPLACEMENT

The Sampling Probe Assembly (A1) is not a field repairable item. A complete assembly is available on an exchange basis (-hp- Part No. 03406-62103) through your local Hewlett-Packard Sales and Service office (See Appendix B for office location).

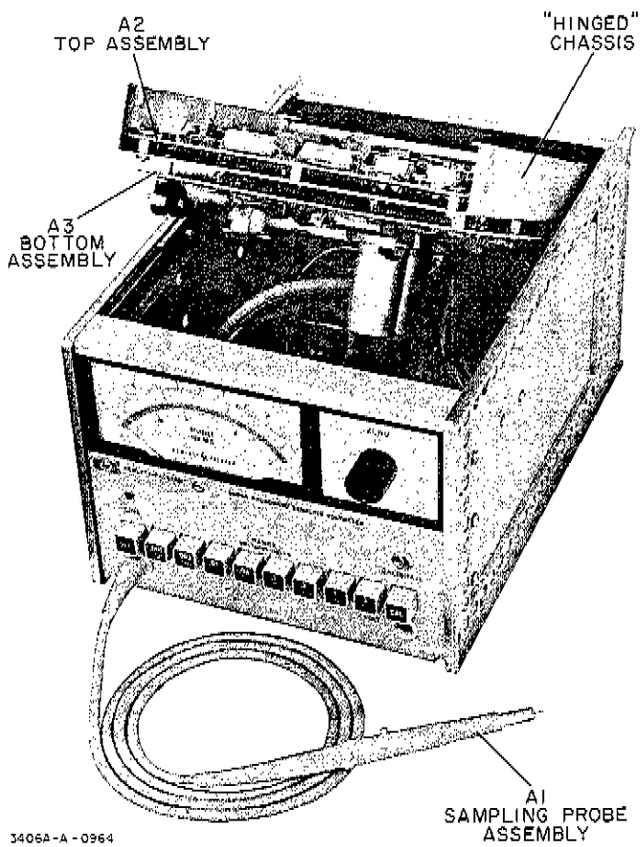
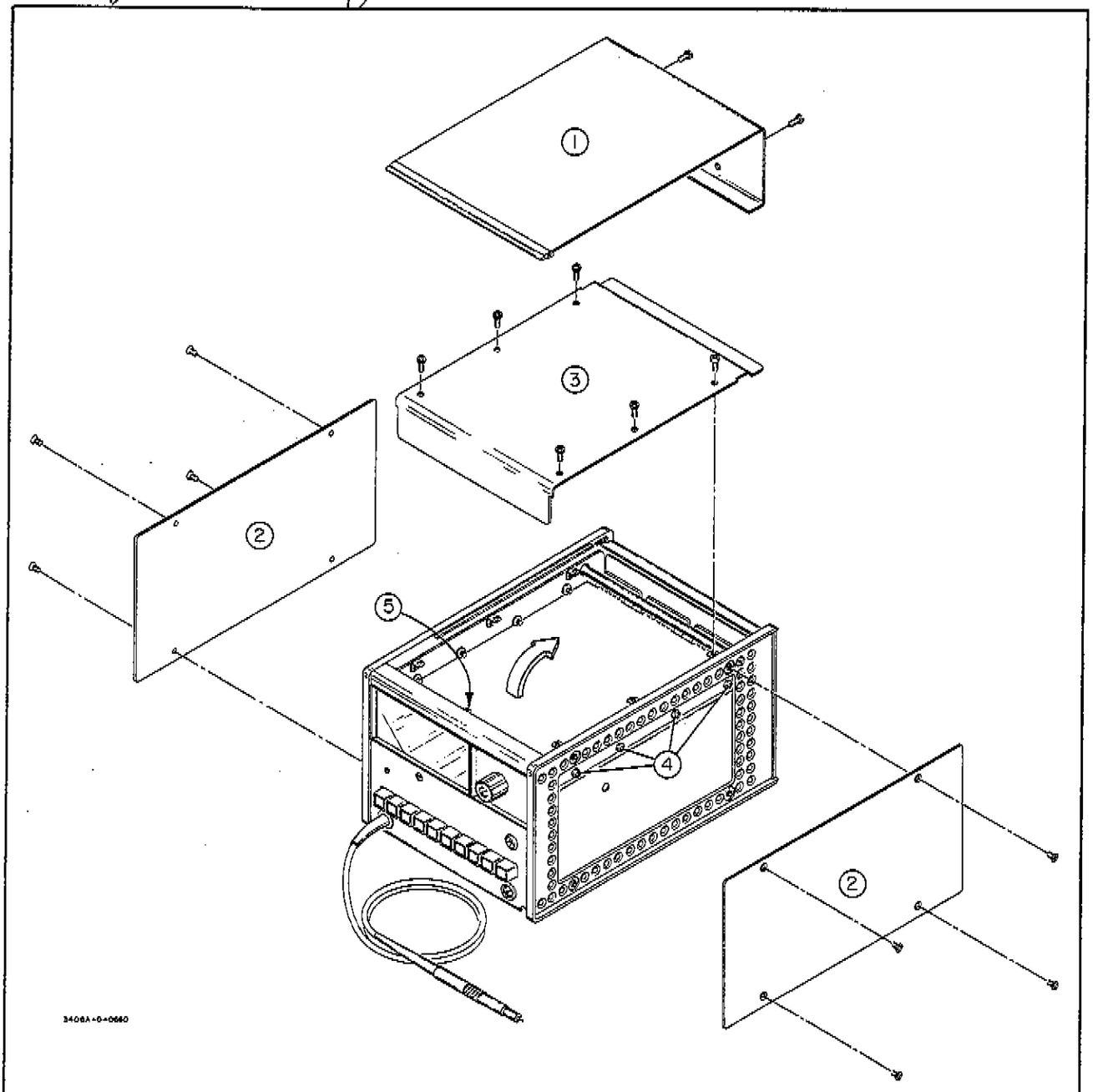


Fig 7-1 Sht 1 of 4



(1) Remove top cover.

(2) Remove both right and left side covers.

NOTE

The instrument is now ready for calibration and adjustment.

(3) Remove the "top shield" to make the + and - 15 v test points and Top Assembly accessible.

(4) Remove the four screws from both the right and left side gussets.

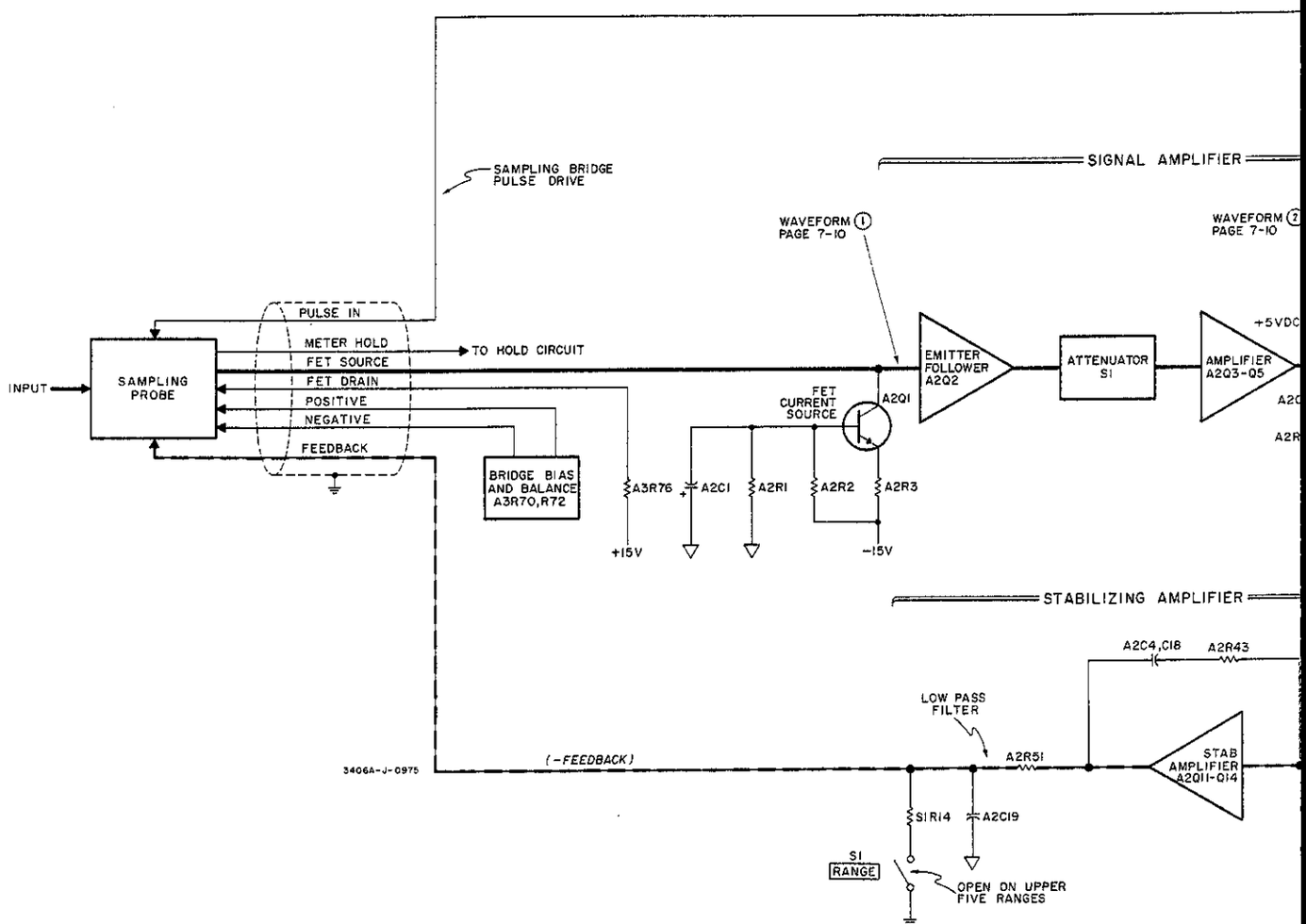
(5) Remove the front-center screw on Top Assembly.

NOTE

The "hinged chassis" may now be lifted up to make the Bottom Assembly accessible.

COVER REMOVAL

Fig 7-1
Sht 2 of 4



right

Top

Fig 7-1
Sht 3 of 4

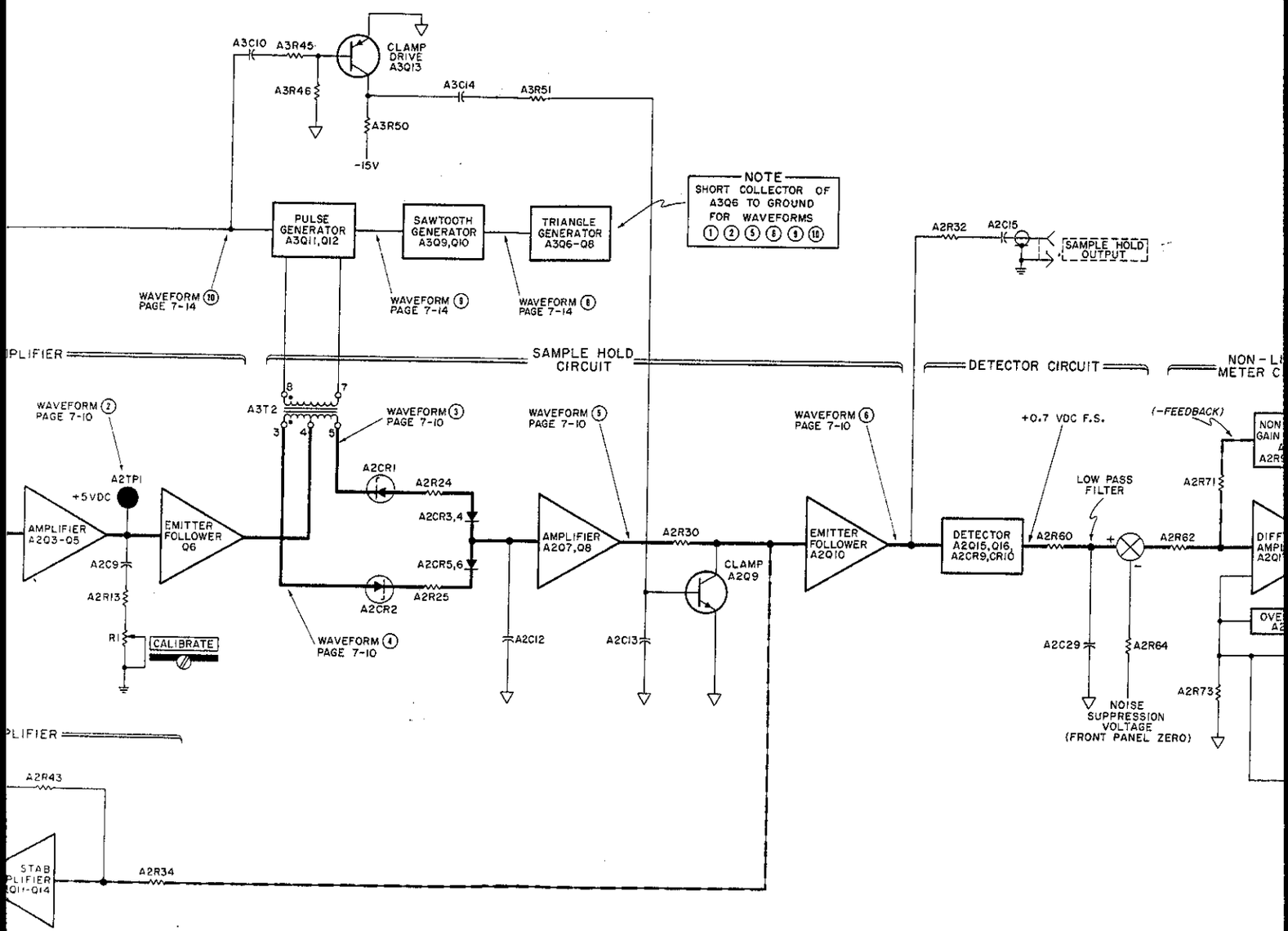


Fig 7-1
Sht 4 of 4

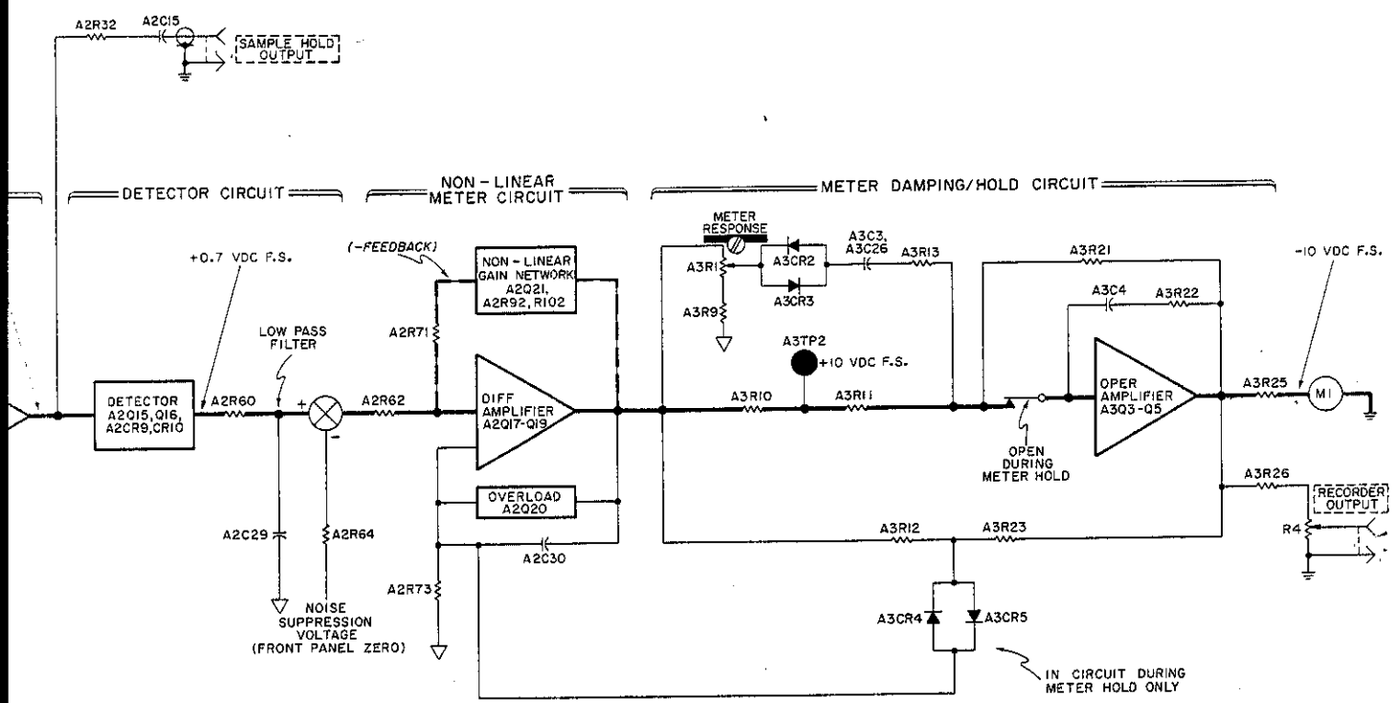


Figure 7-1. Functional Block Diagram and Cover Removal

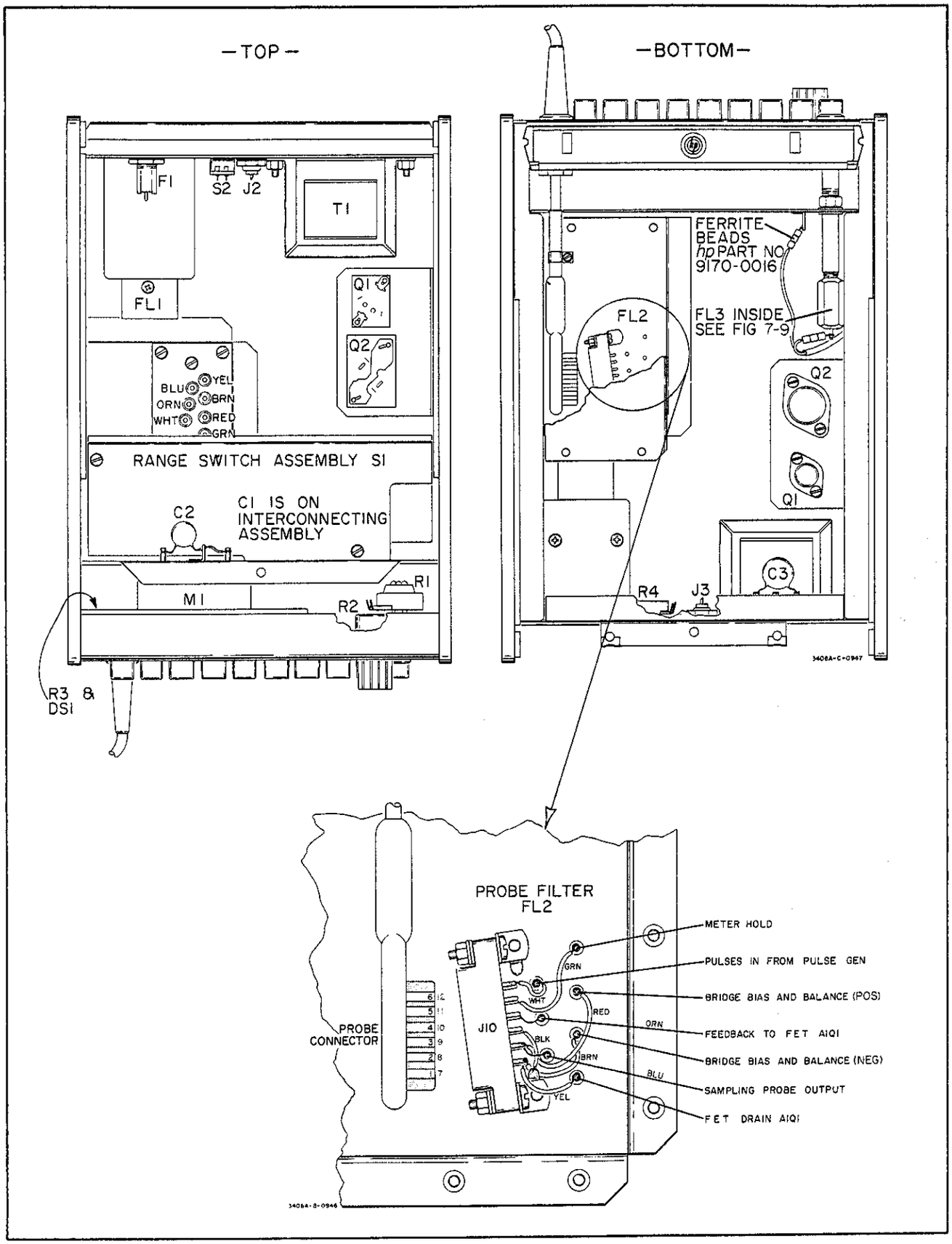
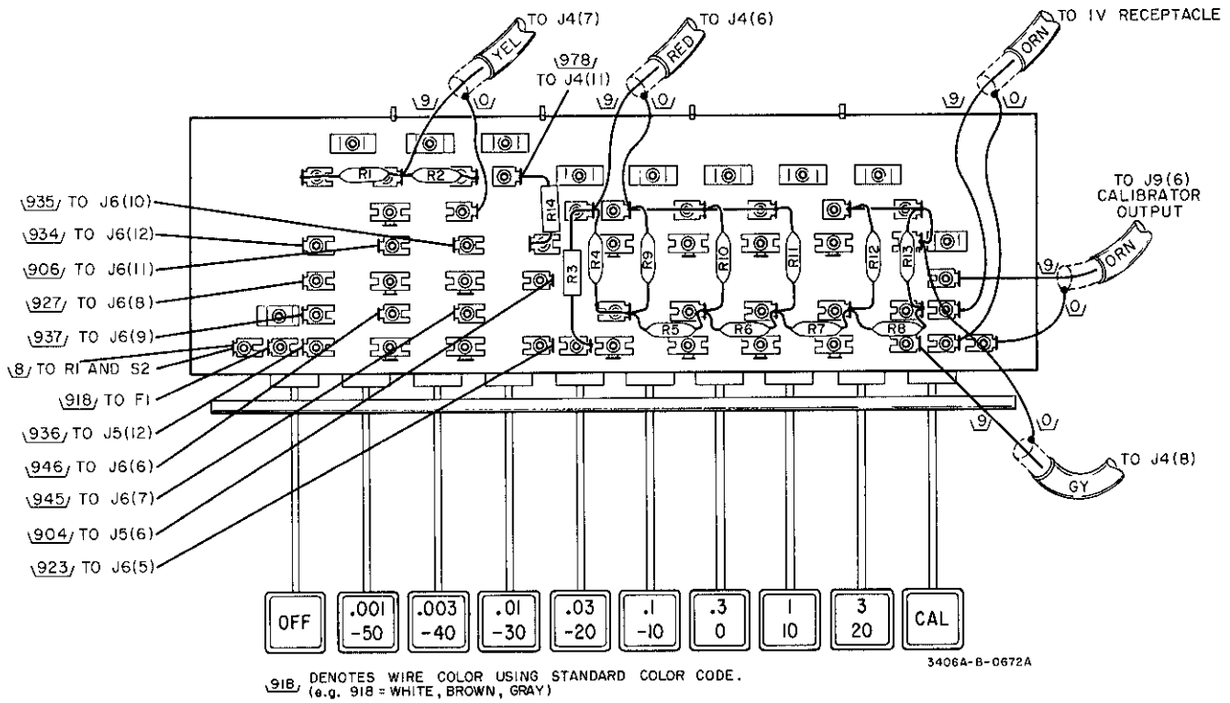


Figure 7-2. Chassis Components



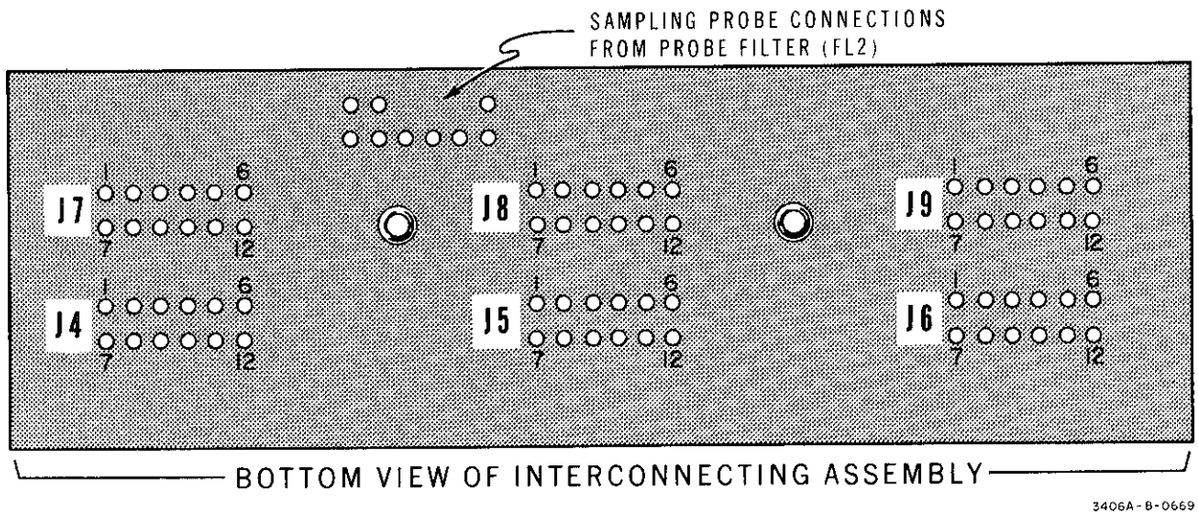
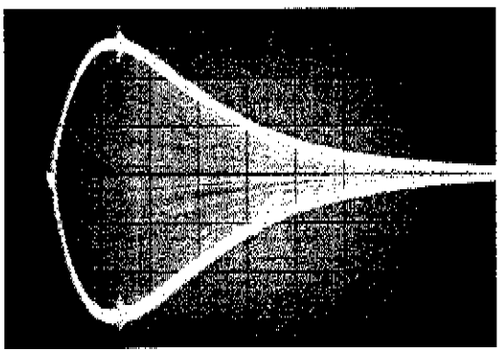


Figure 7-3. Range Switch and Interconnecting Assembly

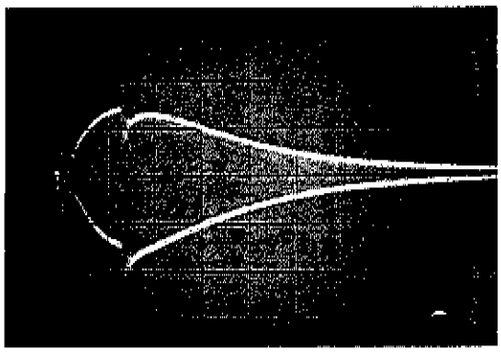
All waveforms should be observed With 10:1 Probe

(1) Sampling Probe Output
(Base of A2Q2)



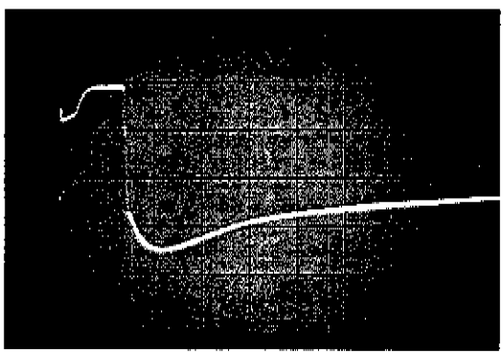
Vert = .1V/cm; sweep = 2μs/cm
AC coupled; sweeping stopped*

(2) Signal Amplifier Output
(A2TP1)



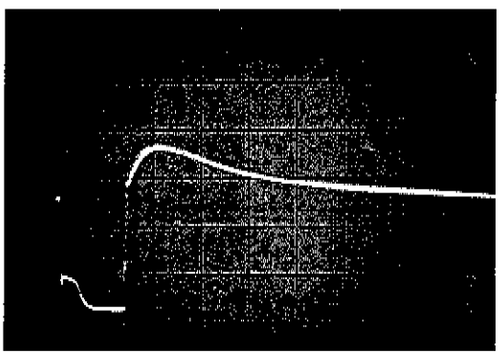
Vert = .05V/cm; sweep = 2μs/cm
AC coupled; sweeping stopped*

(3) Positive Drive Pulse
(Cathode of A2CR1)



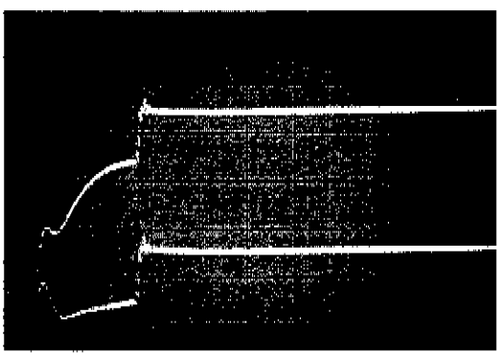
Vert = 5V/cm; sweep = 2μs/cm
AC coupled

(4) Negative Drive Pulse
(Anode of A2CR2)



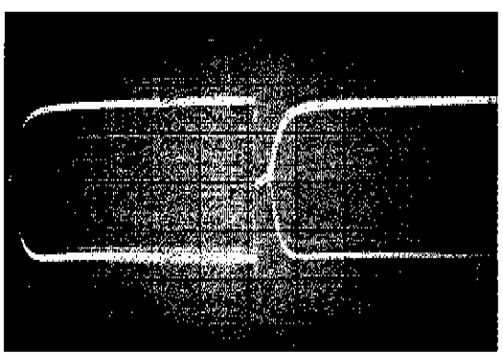
Vert = 5V/cm; sweep = 2μs/cm
AC coupled

(5) (Collector of A2Q8)



Vert = .2V/cm; sweep = 1μs/cm
AC coupled; sweeping stopped*

(6) Sample Hold Output
(Emitter of A2Q10)

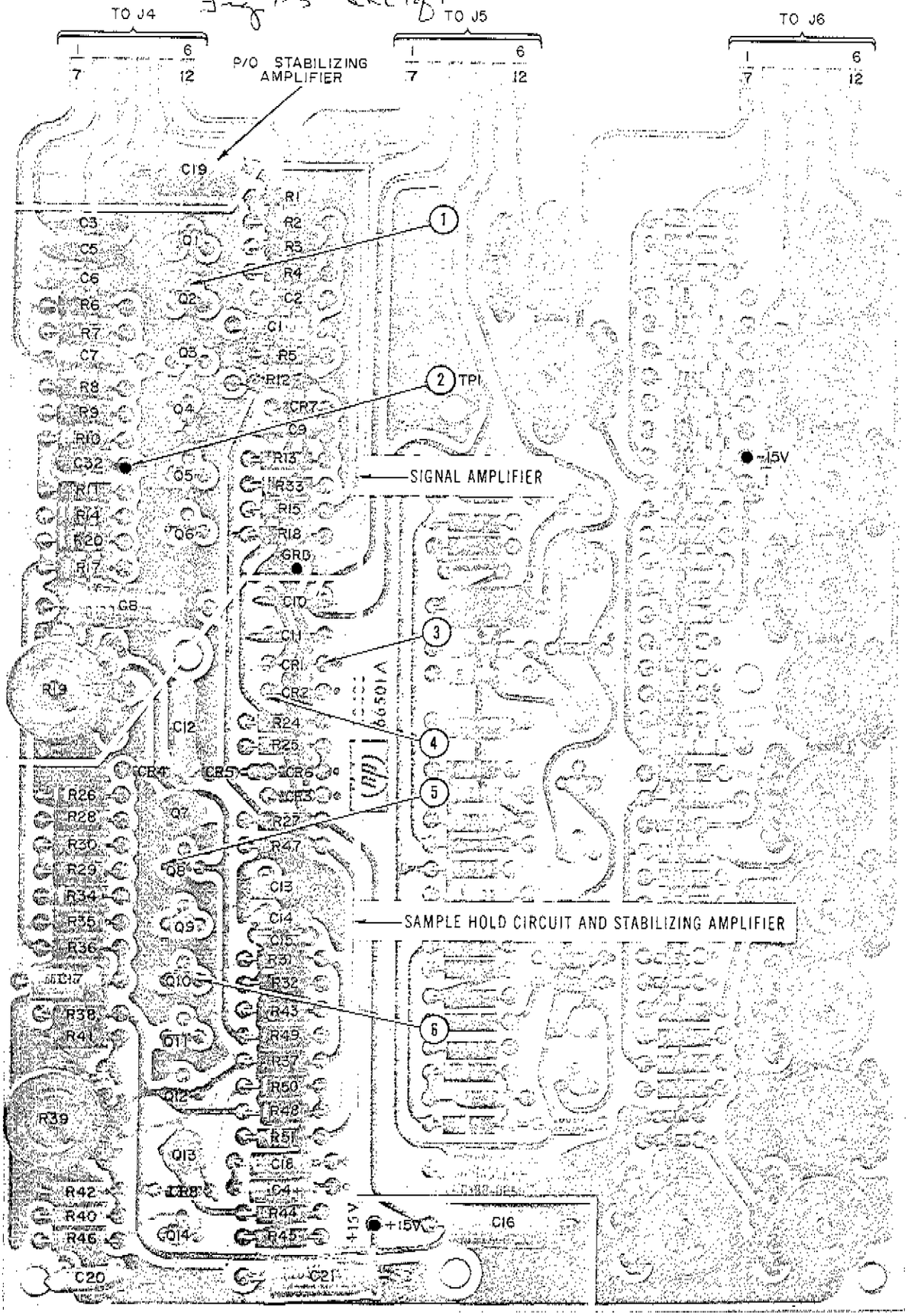


Vert = .2V/cm; sweep = 10μsec
AC coupled; sweeping stopped*

* To stop sweeping, short collector of A3Q6 to ground (Figure 7-8)

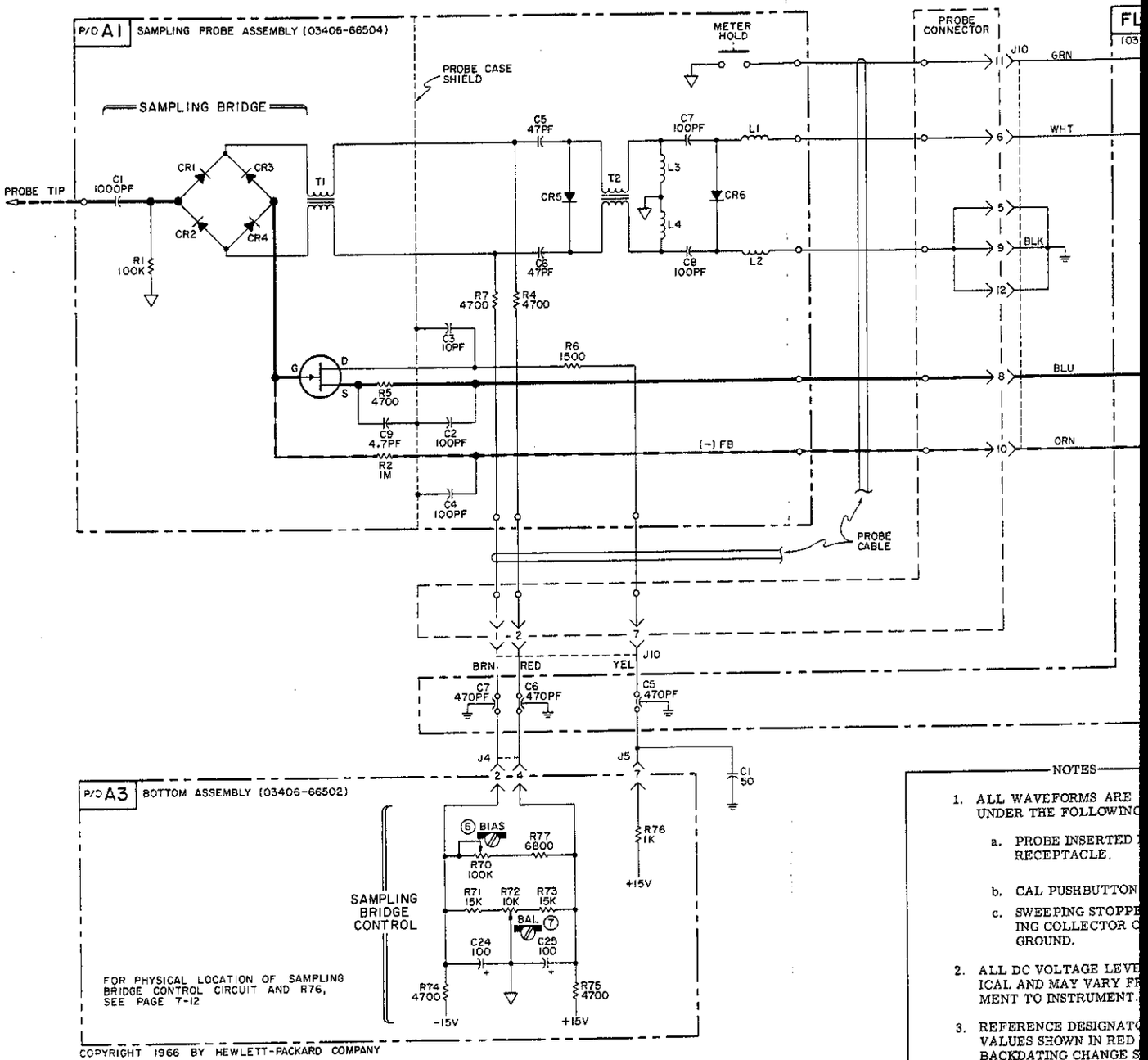
Figure 7-4. Input Circuit Waveforms

Fig 7-5 Sht 1 of 4



A2
TOP ASSEMBLY
(hp Part No. 03406-66501)

Fig 7-5
Sht 2 of 4



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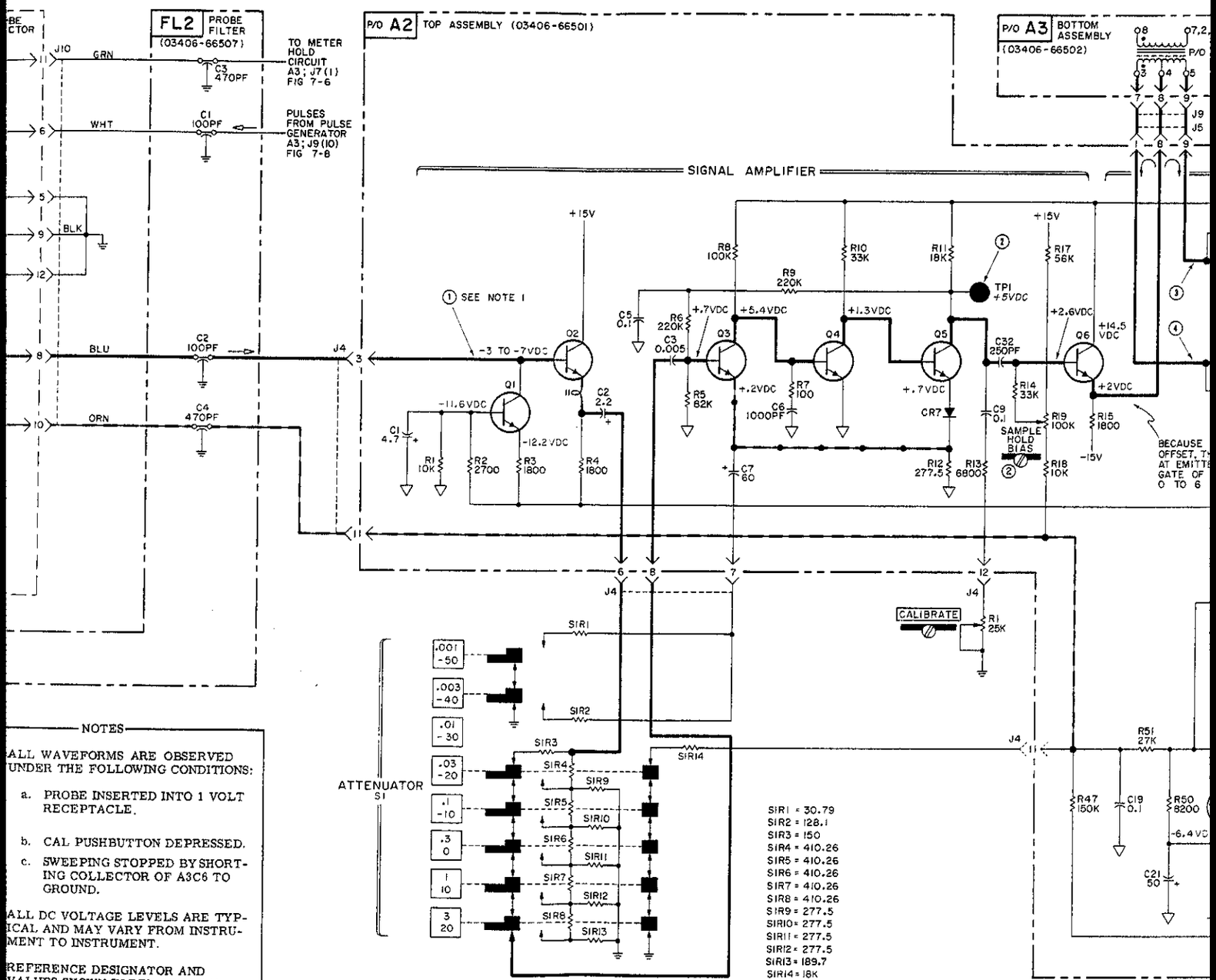
NOTES

1. ALL WAVEFORMS ARE UNDER THE FOLLOWING
   a. PROBE INSERTED RECEPTACLE.
   b. CAL PUSHBUTTON
   c. SWEEPING STOPPE ING COLLECTOR C GROUND.
2. ALL DC VOLTAGE LEVE ICAL AND MAY VARY FR MENT TO INSTRUMENT.
3. REFERENCE DESIGNAT VALUES SHOWN IN RED BACKDATING CHANGE S 7-2 AND 7-3.

Fig 7-5
Sht 3 of 4



NOTES

ALL WAVEFORMS ARE OBSERVED UNDER THE FOLLOWING CONDITIONS:

a. PROBE INSERTED INTO 1 VOLT RECEPTACLE.

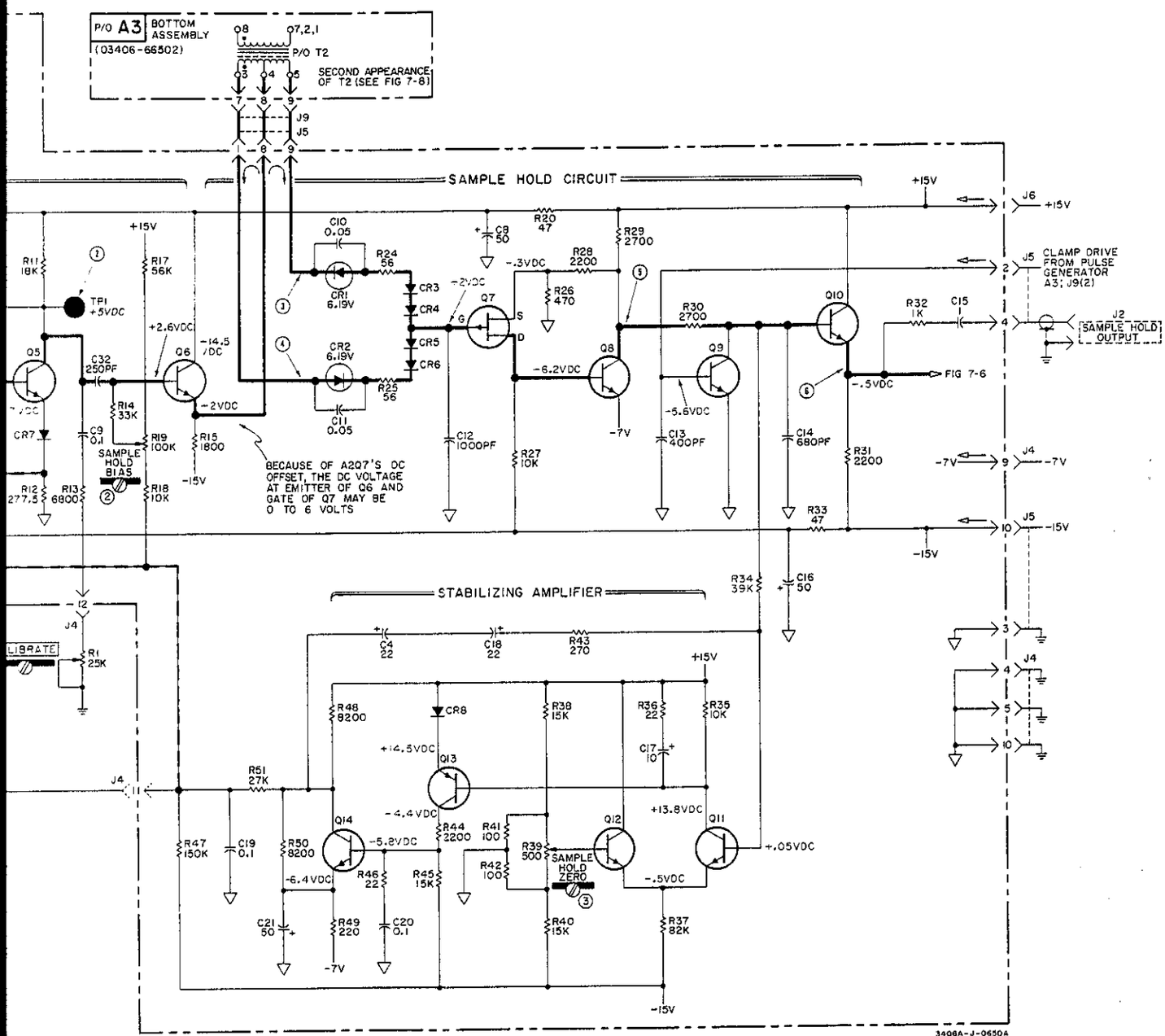
b. CAL PUSHBUTTON DEPRESSED.

c. SWEEPING STOPPED BY SHORTING COLLECTOR OF A3C6 TO GROUND.

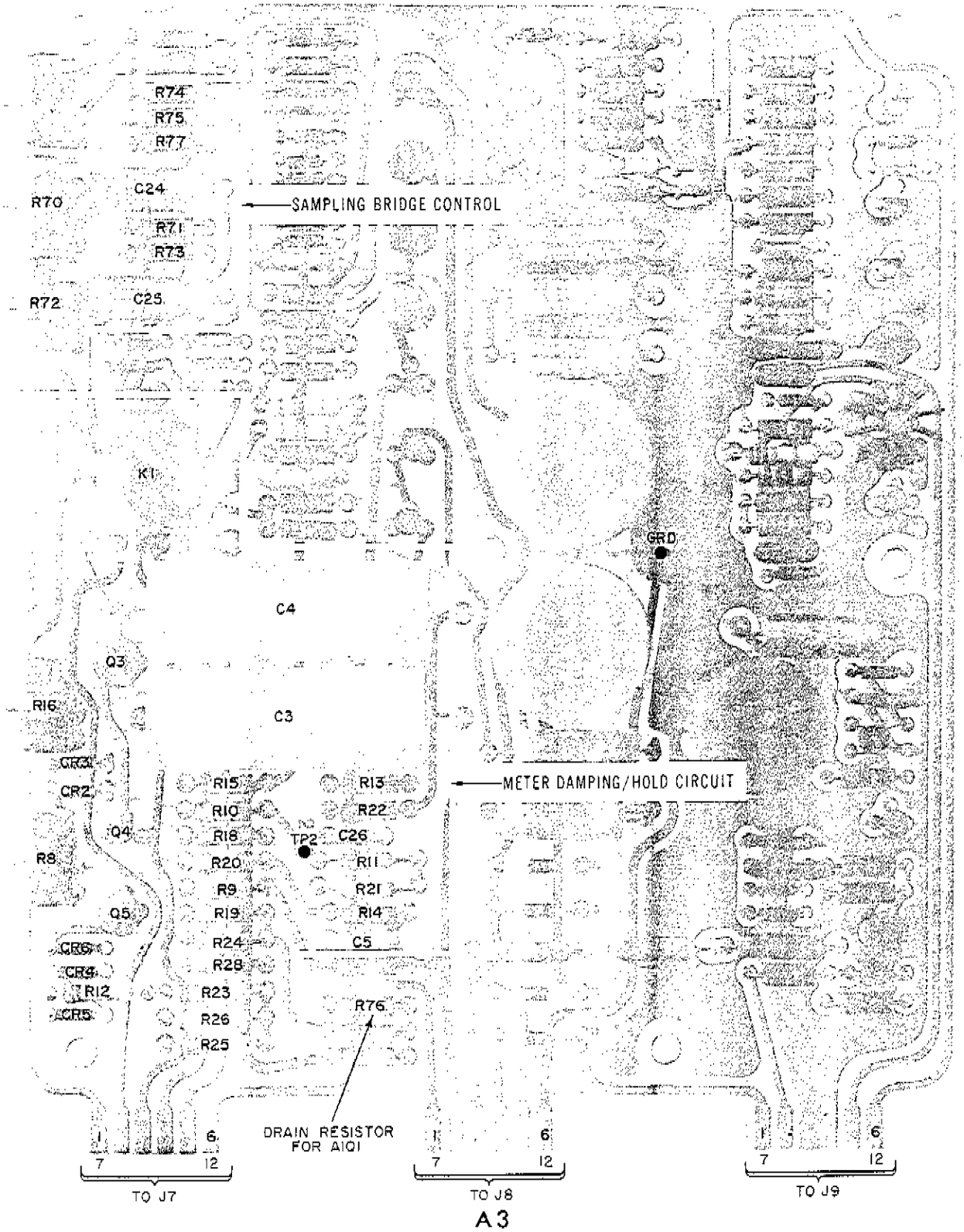
ALL DC VOLTAGE LEVELS ARE TYPICAL AND MAY VARY FROM INSTRUMENT TO INSTRUMENT.

REFERENCE DESIGNATOR AND VALUES SHOWN IN RED DENOTES BACKDATING CHANGE SEE PAGES 7-2 AND 7-3.

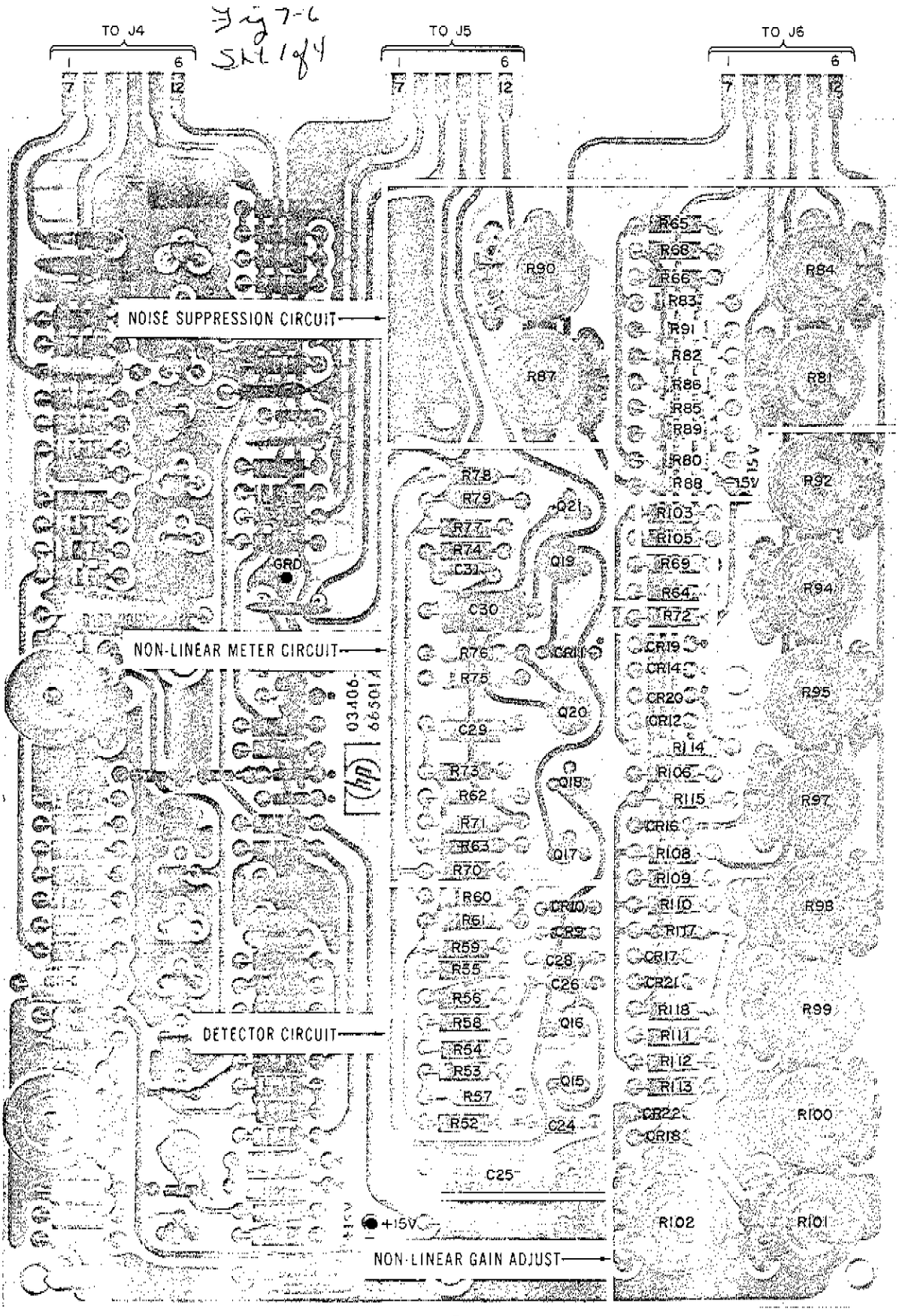
Fig 7-5
Sht 4 of 4



01811-1 Figure 7-5. Input Circuits 7-11.

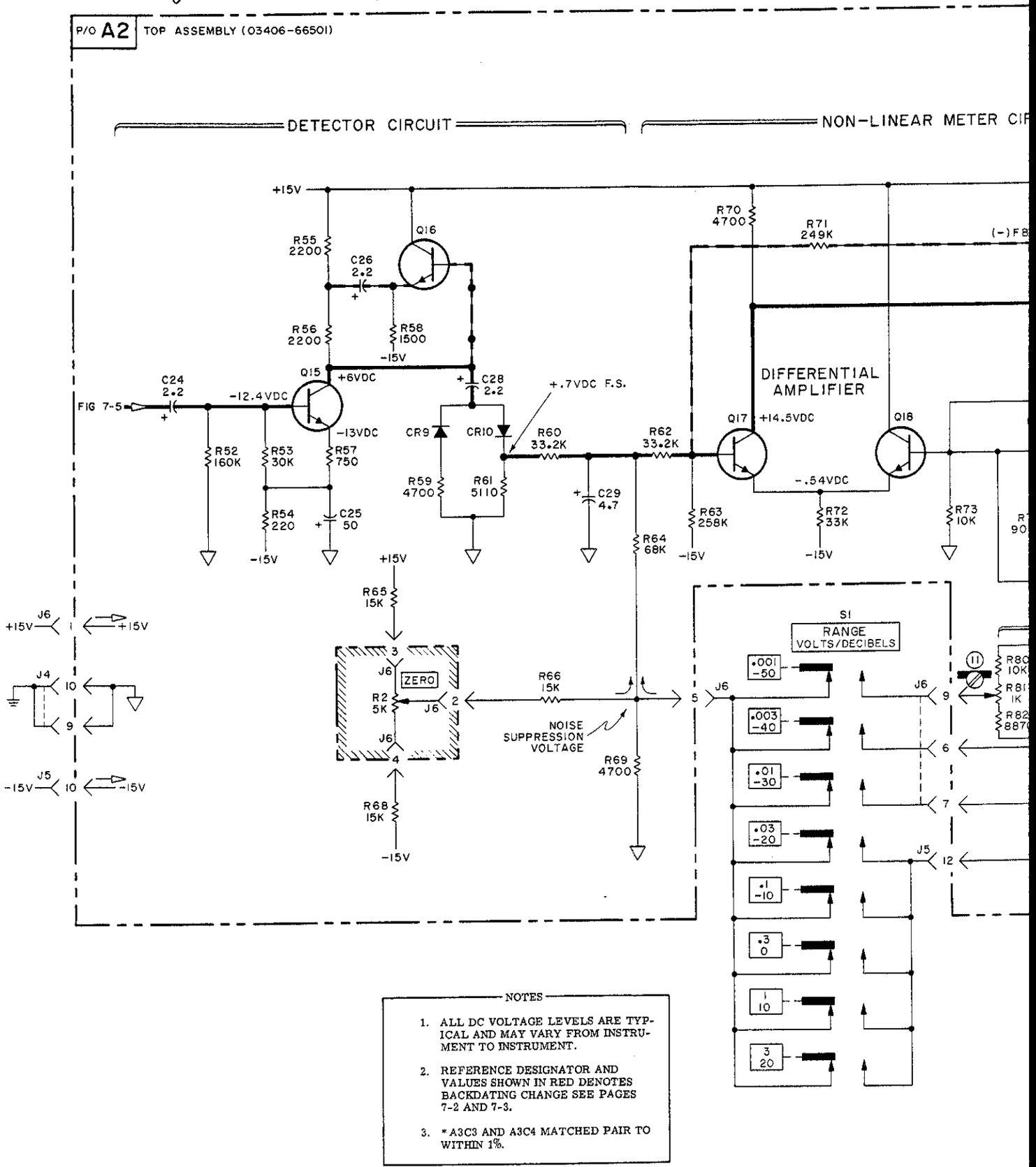


A3
BOTTOM ASSEMBLY
(hp Part No. 03406-66502)



A2
TOP ASSEMBLY
(hp Part No. 03406-66501)

Fig 7-6 Sht 2 of 4



NOTES

1. ALL DC VOLTAGE LEVELS ARE TYPICAL AND MAY VARY FROM INSTRUMENT TO INSTRUMENT.
2. REFERENCE DESIGNATOR AND VALUES SHOWN IN RED DENOTES BACKDATING CHANGE SEE PAGES 7-2 AND 7-3.
3. *A3C3 AND A3C4 MATCHED PAIR TO WITHIN 1%.

Fig 7-6 Sht 3 of 4

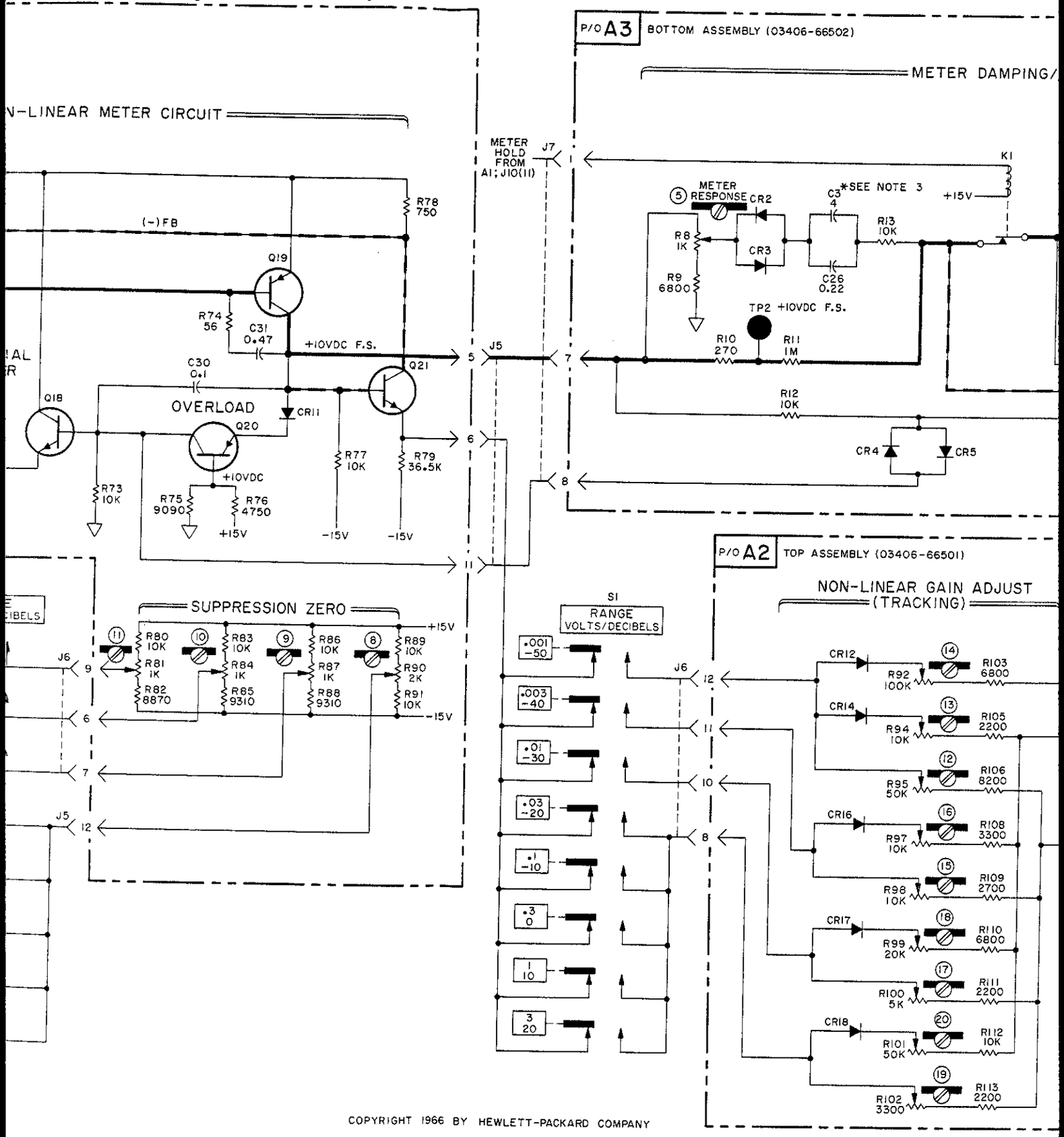


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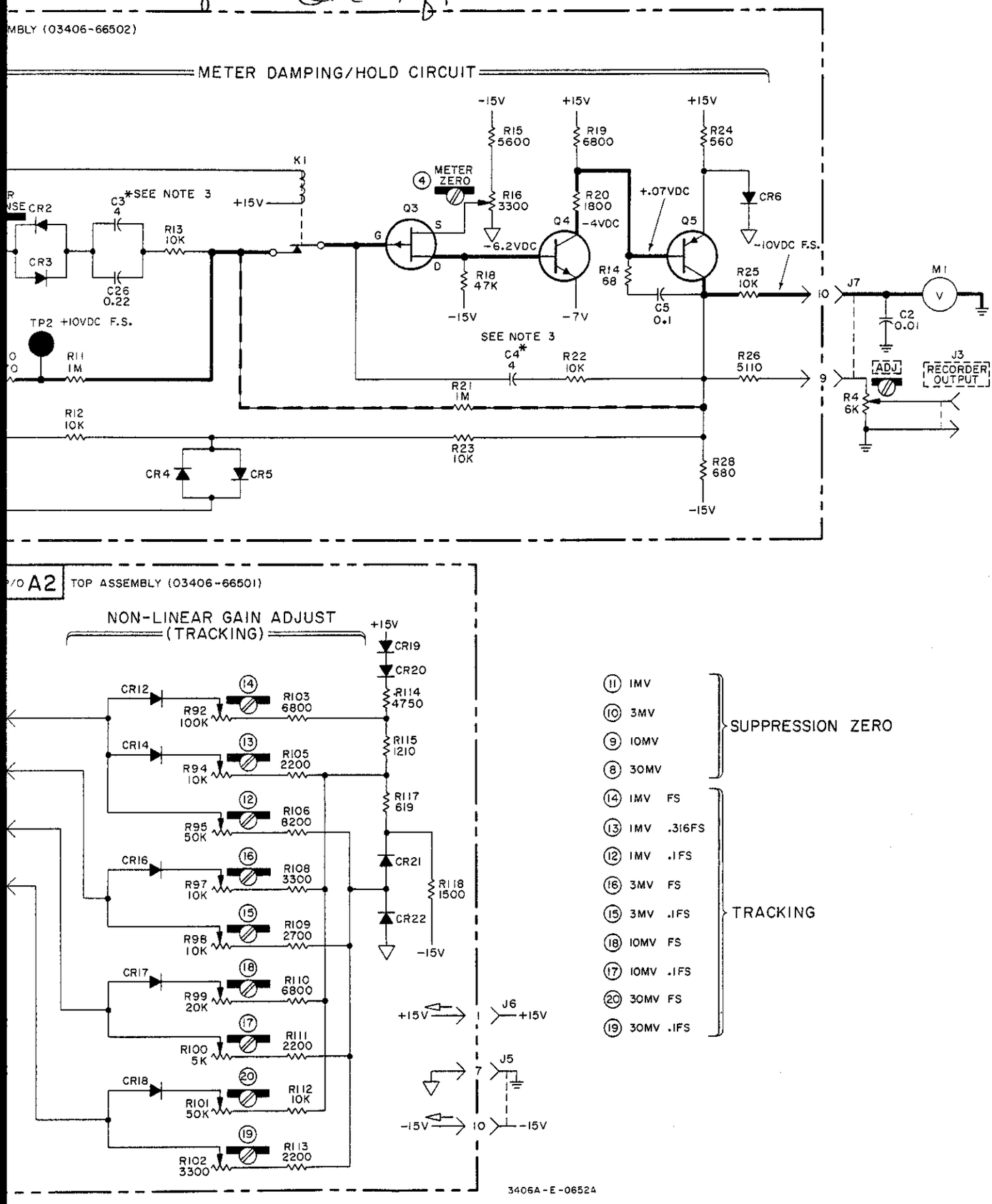
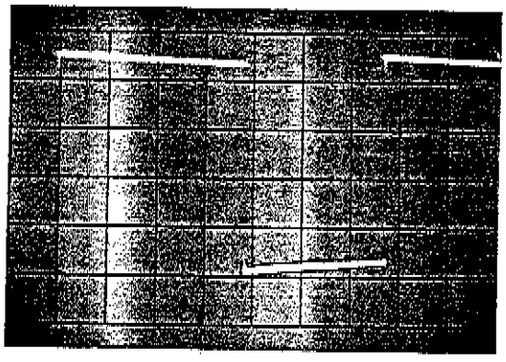
Fig 7-6 Sht 4 of 4



01811-1 Figure 7-6. Metering Circuits

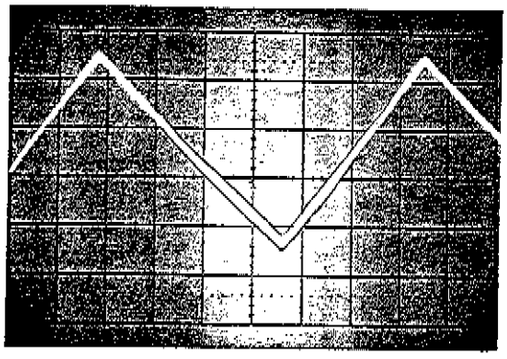
All waveforms should be observed with 10:1 Probe

(7) (Collector of A3Q7)



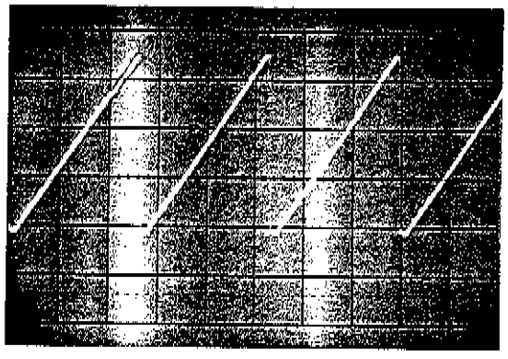
Vert = 2V/cm; sweep = 2μs/cm
AC coupled; Ext. trigger

(8) Triangle Generator Output
(Collector of A3Q8)



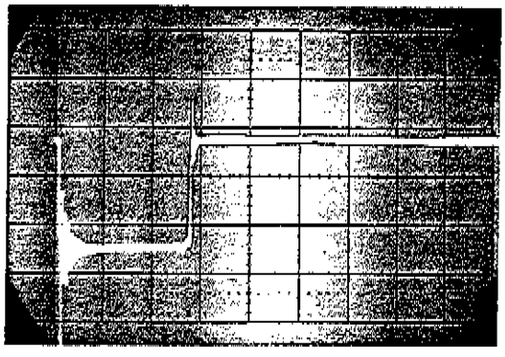
Vert = 2V/cm; sweep = 20μs/cm
AC coupled; Ext. trigger-collector A3Q7

(9) Sawtooth Generator Output
(Collector A3Q9)



Vert = 2V/cm; sweep = 20 μs
AC coupled; sweeping stopped*

(10) Pulse Generator Output
(Anode of A3CR14)

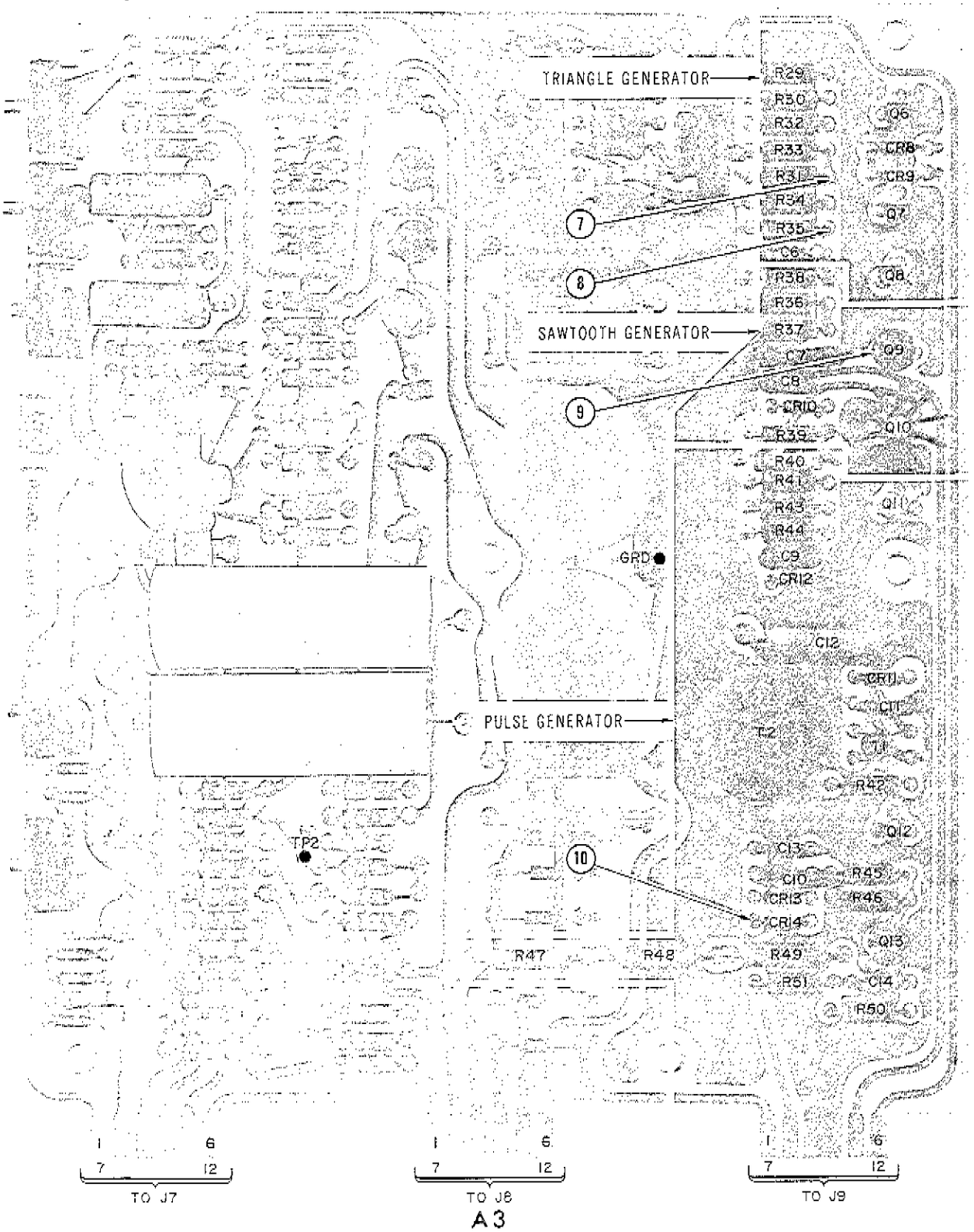


Vert = 5V/cm; sweep = 1μs/cm
AC coupled; sweeping stopped*

* To stop sweeping, short collector of A3Q6 to ground (Figure 7-8).

Figure 7-7. Pulse Generator Circuit Waveforms

Fig 7-8 Sht 1 of 3

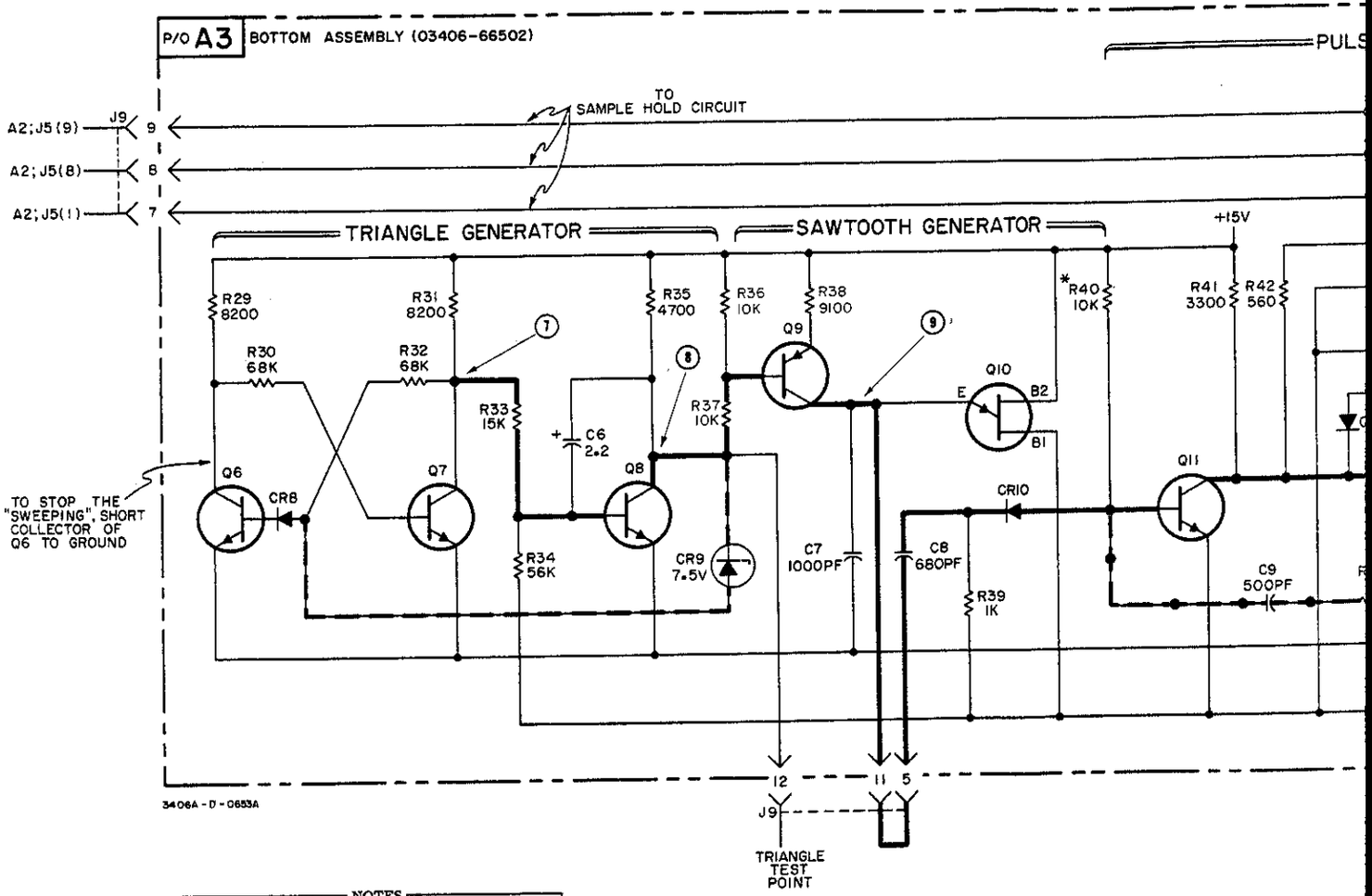


A3

BOTTOM ASSEMBLY

(hp Part No. 03406-66502)

Fig 7-8
Sht 2 of 3



NOTES

1. WAVEFORMS (9) AND (10) ARE OBSERVED WITH THE COLLECTOR OF A3Q6 SHORTED TO GROUND.
2. ALL DC VOLTAGE LEVELS ARE TYPICAL AND MAY VARY FROM INSTRUMENT TO INSTRUMENT.
3. REFERENCE DESIGNATOR AND VALUES SHOWN IN RED DENOTES BACKDATING CHANGE SEE PAGES 7-2 AND 7-3.

Fig 7-8
Sht 3 of 3

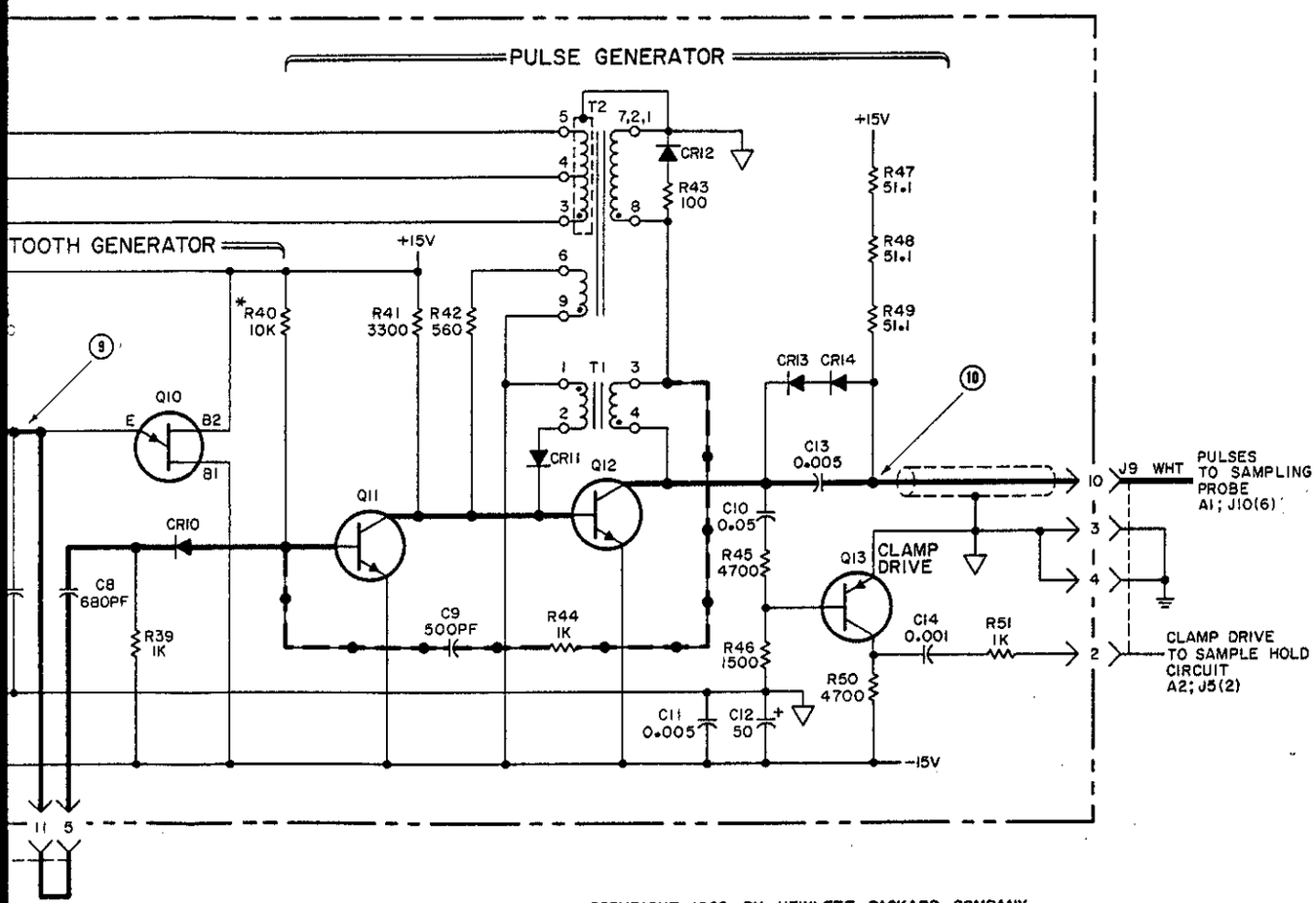


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Figure 7-8. Pulse Generator Circuits

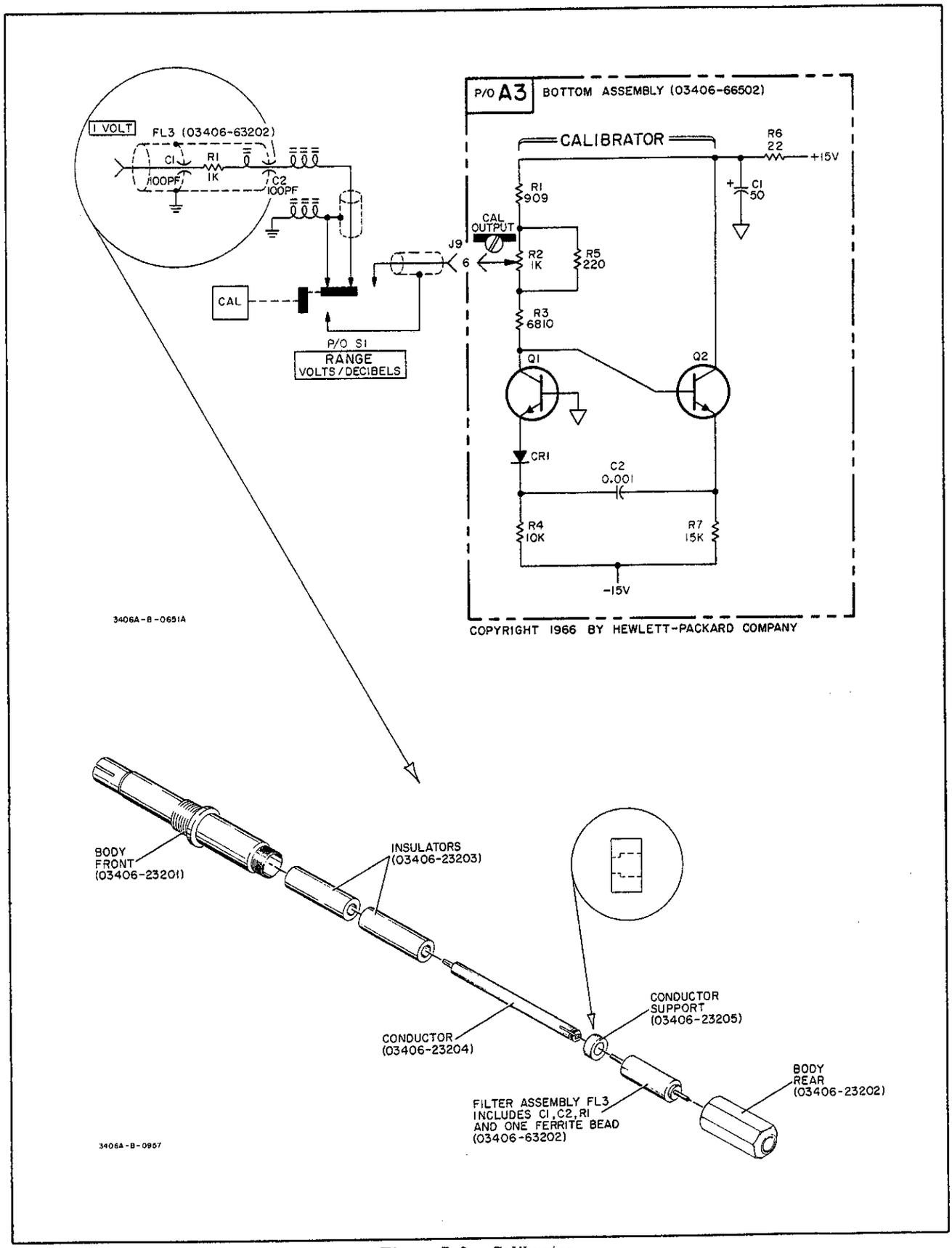
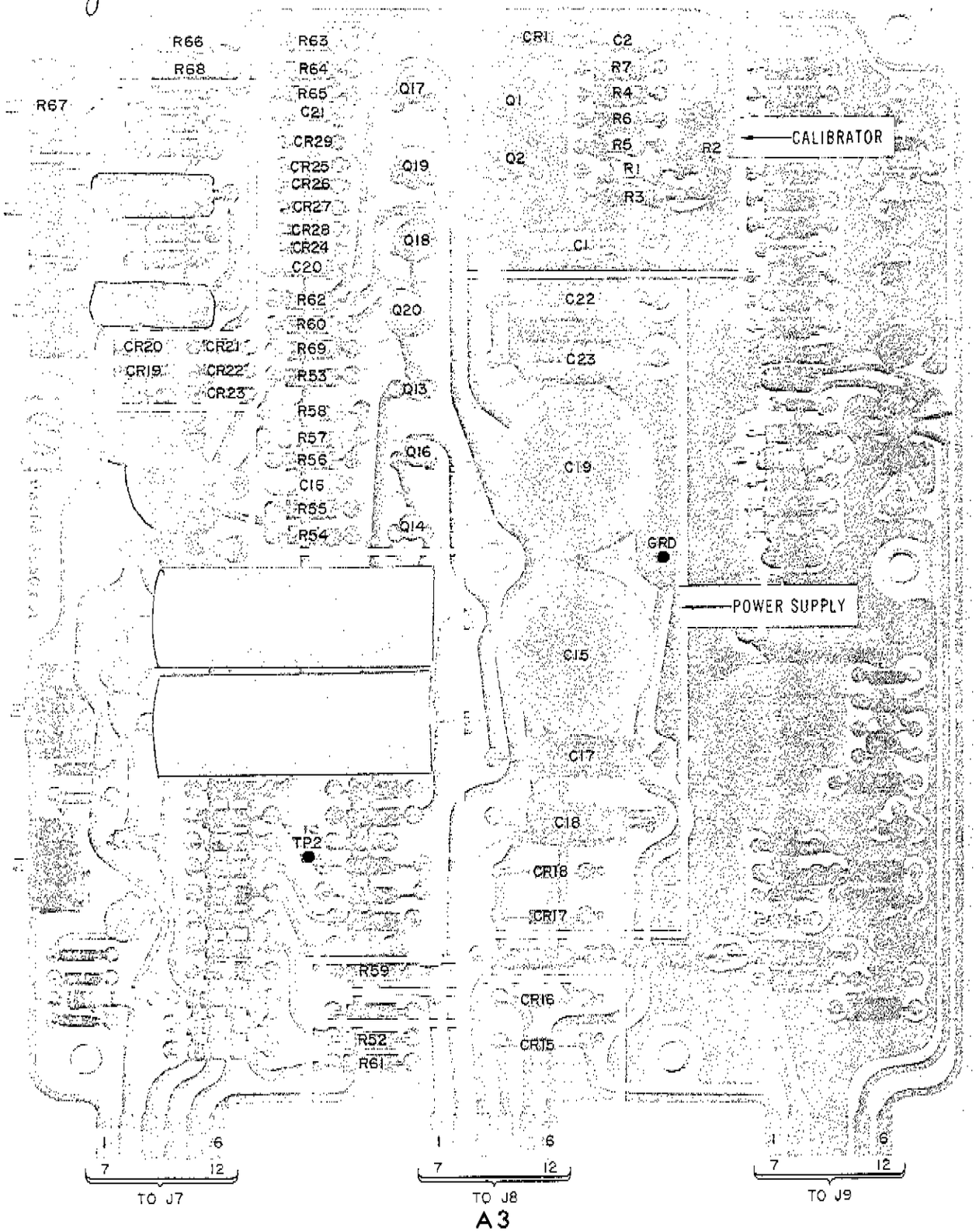


Figure 7-9. Calibrator

Fig 7-10 Sht 1 of 3

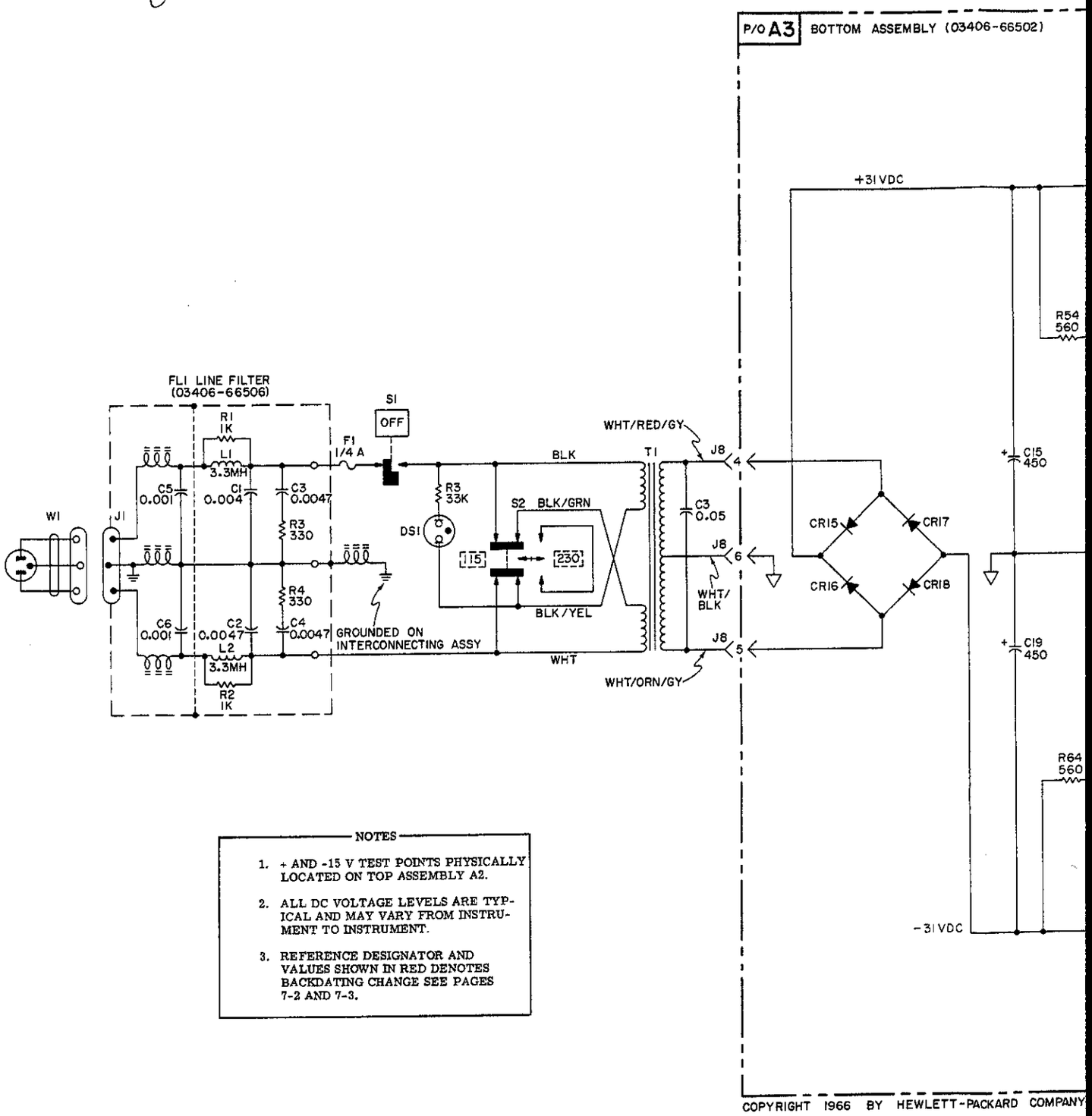


A3

BOTTOM ASSEMBLY

(hp Part No. 03406-66502)

Fig 7-10
sht 2 of 3



NOTES

1. + AND -15 V TEST POINTS PHYSICALLY LOCATED ON TOP ASSEMBLY A2.
2. ALL DC VOLTAGE LEVELS ARE TYPICAL AND MAY VARY FROM INSTRUMENT TO INSTRUMENT.
3. REFERENCE DESIGNATOR AND VALUES SHOWN IN RED DENOTES BACKDATING CHANGE SEE PAGES 7-2 AND 7-3.

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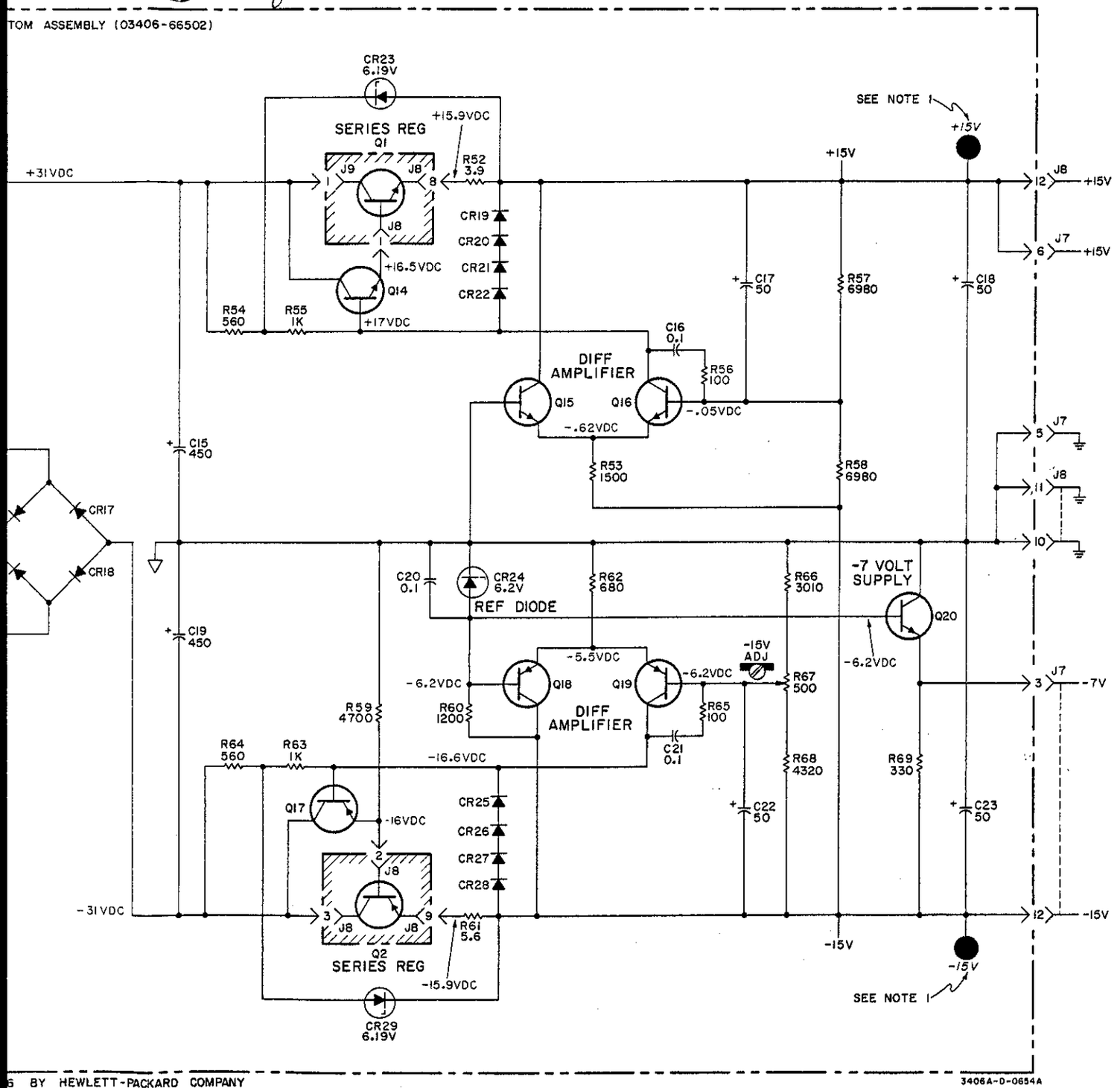
Fig 7-10
Sht 3 of 3



01811-1 Figure 7-10. Power Supply Circuit 7-17.

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidaire Co.	Colton, Calif.
00335	Westrex Corp.	New York, N. Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N. J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N. J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordnit Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Fulton Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic Inc o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
05824	The Bassick Co.	Bridgeport, Conn.
06135	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E. T. A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amalon Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semicon Division of Nuclear Corp. of America	Phoenix, Arizona
06817	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08789	Blinn, Delbert, Co.	Pomona, Calif.
08858	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	San Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermoflex	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Semi-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
53743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Guderian Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Philips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jeannings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoeli Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Watlingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80284	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Tried Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	.....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Conner Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Berbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

SUPPLEMENTAL CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
000LF	Don Wells, Inc.	San Leandro, Calif.
000LK	United International	Hollywood, Calif.
80089	R B M	Logansport, Ind.
96508	Xcellite, Inc.	Orchard Park, N.Y.

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